Chapter

Atomic Structure

Lesson One

From: Introduction of atomic structure.

Until: Before atomic emission spectra.

Lesson Two

From: Atomic emission spectra.

Until: Before the quantum numbers.

Lesson Three

From: The quantum numbers.

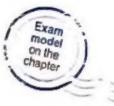
Until: Before principles of distributing electrons.

Lesson Four

From: Principles of distributing electrons.

Until: The end of the chapter.





2

The Periodic Table and Classification of Elements

Lesson One

From: The long form (modern)

periodic table.

Until: Before trends and periodicity of

properties in the periodic table.

Lesson Two

From: Trends and periodicity of

properties in the periodic table.

Until: Before metallic and nonmetallic property.

Lesson Three

From: Metallic and nonmetallic property.

Until: Before the oxidation numbers.

Lesson Four

From: The oxidation numbers.

Until: The end of the chapter.



18 Open Book exam models, including:

- Exam of the ministry of Education 2021
- Questions of the exam of 2020
- * Guiding model of the Ministry of Education.
- 15 exam models on the first term curriculum.

CHAPTER

Atomic Structure

Lesson One

From: Introduction of atomic structure.

Until: Before atomic emission spectra.

Lesson Two

From: Atomic emission spectra.

Until: Before the quantum numbers.

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Until: The end of the chapter.

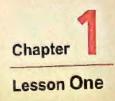
Exam model on the chapter

Learning outcomes

Ey the end of this chapter, the student will be able to :

- · Recognize the historical background of atomic structure.
- . Describe the properties of cathode rays.
- . Discuss Ratherford's atomic model.
- · Recognize Bohr's atomic model.
- . Define the reasons of the inadequacy of Bohr's model.
- . Construes the modification introduced by the modern atomic theory.
- . Explain the concepts of electron cloud and orbital.
- · Define the four quantum numbers.
- * Distribute electrons of any atom considering the building-up principle. Hund's rule and Pauli's exclusion principle
- · Appreniate the efforts of scientists in the development of chemistry.





From Introduction of atomic structure

Until Before atomic emission spectra



Evolution of the concept of the atomic structure



Scientists were interested in studying the atomic structure

• Heisenberg.

Pauli.

Schrödinger.

Bohr.

O De Broglie.

6 Einstein.

Planck.

Long time ago man wondered about the nature of matter and its structure ?!

Through the trials done by the scientists to answer this question across different eras, the concept of the atomic structure is evolved (developed).

In the following, the historical evolution of atomic structure concept will be discussed:

Democritus's idea.

Boyle's idea.

Thomson's model of the atom.

Bohr's model of the atom.

2 Aristotle's idea.

Dalton's model of the atom.

6 Rutherford's model of the atom.

8 The modern atomic theory.

Democritus's (Greek philosopher) idea

He imagined the possibility of dividing any piece of matter to smaller parts, then dividing those parts into smaller particles and so on, until an indivisible (indestructible) fragment is obtained, he named it an "atom".





Democritus's atomic concept

Note atom in

Gold atom

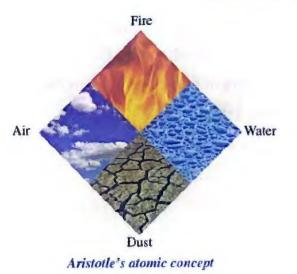
atom in the Greek language is a word of two sections:

- · a means no.
- tom means divide.

2 Aristotle's idea (4th Century B.C)

- He rejected the former concept of the atom and believed that matter whatever its nature - is composed of four components, which are water, air, dust and fire.
- It was believed that cheap metals as iron or copper can be changed into precious ones as gold by changing the proportions of these four constituents.
- This illogical idea had blocked the development in chemistry science for more than thousand years .. G.R.? Because the scientists were busy trying to change cheap metals into precious ones.





3 Boyle's idea (1661)

The Irish scientist Boyle rejected Aristotle's idea about the nature of matter and gave the first definition of the element.

Element is a pure simple substance that can't be changed to simpler forms by the traditional chemical methods.



7

Dalton's model of the atom (1803)

The English scientist John Dalton stated the first theory about the atomic structure.



The main postulates of Dalton's atomic theory

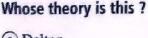
- 1 The element is composed of very minute particles, named atoms.
- 2 The atom is a very minute indivisible solid particle.
- Masses of atoms of the same element are similar, but they differ from one element to another.
- 1 The compounds are formed by the combination of atoms of different elements in simple numerical ratios.



Dalton's atom (solid, indivisible)

Test Yourself

The opposite figure represents one of the postulates of an atomic theory that you have studied, these balls represent the atoms of two different elements.



- a Dalton.
- (b) Democritus.
- (c) Aristotle.
- d Boyle.

Idea of answering:

It is shown in the figure that the masses of the atoms of the same elements are but they from one element to another.

This is exactly one of the postulates of's theory.

Answer: The correct choice is

Thomsas

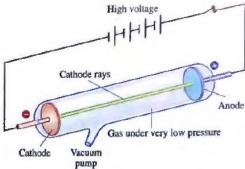
Thomson's model of the atom (1897)

The scientist Thomson carried out many experiments on the electric discharge through gases, from which he had discovered the cathode rays.

Discovery of cathode rays (1897):

- It was known that gases do not conduct electricity under normal conditions of pressure and temperature.
- However, gases conduct electricity in a discharge tube whose two electrodes are connected to an electric source with a suitable potential difference between its electrodes and under very low pressure.
- If the potential difference between the two electrodes of the discharge glass tube increases to about 10000 volts, a stream of invisible rays will be emitted from the cathode (the negative electrode), causing a fluorescent glow on hitting the tube wall. These rays were named "cathode rays".

Cathode rays are streams of invisible rays emitted from the cathode of a discharge tube in which the pressure of the gas is very low and the potential difference between the two electrodes is about 10000 volts.

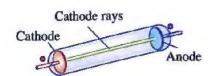


Generating cathode rays

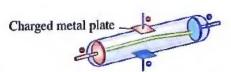
• It was later known that these rays are composed of minute particles named "electrons".

Properties of cathode rays:

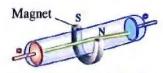
- 1 They are formed of very fine negatively charged particles with negligible masses (electrons).
- 2 They move in straight lines.
- They have a thermal effect.
- They are affected by both electric and magnetic fields.
- They do not vary with the nature of cathode material, or that of the used gas, this is a strong evidence that they are a fundamental constituent of any matter. In the light of the electrical discharge experiment, Thomson suggested a new atomic model.



Move in straight lines



Negatively charged particles are affected by electric field

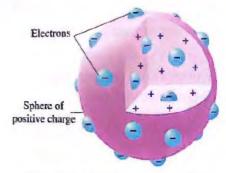


Affected by magnetic field

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The postulate of Thomson's model

He considered the atom as a solid sphere of uniform positive electric charges in which a number of negatively charged electrons is embedded to make the atom electrically never at the second s



Thomson's model of atom (solid)



Thomson's model of atom resembles a watermelon

Test Yourself

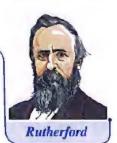
Dalton and Thomson agreed on that carbon atom

- (a) has no spaces within it.
- (b) is electrically neutral.
- © contains negative electrons.
- d is a homogenous sphere.

Answer: The correct choice is

6 Rutherford's model of the atom (1911)

Rutherford's students Geiger and Marsden had performed his famous laboratory experiment.



Rutherford's experiment

The used tools:

- A deep lead box containing a source of alpha particles inside it.
- A metal sheet lined with a layer of zinc sulphide ZnS
- A very thin gold foil.

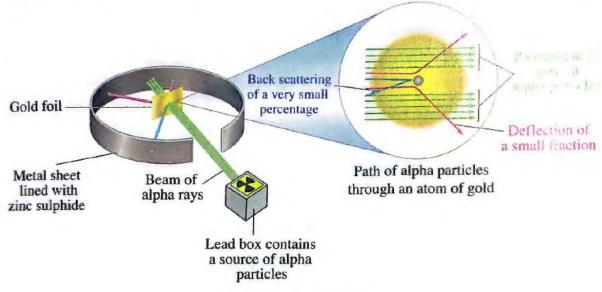


G.R. Zinc sulphide ZnS is used in detecting the invisible alpha particles.

As they glow (flash) at the positions where they collide with zinc sulphide.

The procedure:

- 1 The positive alpha particles (α) were allowed to collide with the metal sheet, where it was possible to define the location and the number of alpha particles by counting the flashes which appeared on the metal sheet.
- 2 A very thin gold foil was placed between the beam of alpha particles and the metal sheet.



Rutherford's experiment

Rutherford recorded his observations and reached the following conclusions:

Observations:

- (1) The appearance of a large !* The penetration of number of flashes at the same positions where they appeared before placing the gold foil.
- (2) The appearance of some flashes on the other side of the metal foil (in front of the foil).
- (3) The appearance of some flashes on both sides of the position where they appeared before and after placing the gold foil.

Explanations:

- the majority of α-particles through the gold foil without deflection.
- * A very small percentage of α-particles did not penetrate! the gold foil and reflected (bounced) back.
- * A small fraction of a-particles penetrated the foil! but were deflected from their path.

Conclusions:

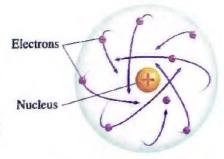
- * Most of the atomic volume is an empty space (i.e. the atom is not a solid ball as proposed by Dalton and Thomson).
- * The atom contains a tiny part of a very high density, and most of the atomic mass is concentrated in this part (was named the nucleus).
 - * The dense part of the atom (where most of the atomic mass is present) has a positive charge similar to that of a-particles, so they were repelled on approaching to this part (the nucleus).

Based on his experiment and other else, Rutherford designed the first atomic model on trial basis.

The postulates of Rutherford's atomic theory

Atom:

- It is an extremely small sized particle.
- It has a complicated structure which resembles the solar system, since it's composed of a central nucleus (representing the sun), and the electrons revolve around it (representing the planets).



Rutherford's atomic model

Nucleus:

- It is much smaller than the atom and most of the atomic mass is concentrated in it.
- There is a vast space between the nucleus and the orbits of electrons (i.e. the atom is not solid).
- It is positively charged.

3 Electrons:

- They have negligible mass compared to that of the nucleus.
- Their charge is negative and equals the nuclear positive charge (i.e. the atom is electrically neutral).
- They travel around the nucleus at a tremendous speed in special orbits, despite the mutual attraction between them and the nucleus.
 This attraction force is equal in quantity and opposite in direction to the centrifugal force resulting from their revolving around the nucleus.

G.R. The electron does not fall into the nucleus despite the attraction between them.

Because the centrifugal force on the moving electron is equal in the magnitude (quantity) and opposite in direction to the attractive force between the nucleus and the electron.

Drawback of Rutherford's atomic model

Rutherford's theory had failed to explain the atomic structure .. G.R.?

Because it didn't explain the system in which electrons revolve around the nucleus.

Worked Example

The opposite figure represents the path of a beam of α -particles between two metal sheets in vacuum conditions.

What happens to the reading of the sensitive instrument upon charging the two metal sheets with different electrical charges?

Source of α-particles

Metal sheet

Sensitive instructed to detect number of Metal sheet α-particles

- (a) It does not change.
- (b) It increases.
- © It decreases.
- d It increases for a period of time, then it returns to the initial reading.

Idea of answering:

- : Alpha particles are positively charged.
- : Upon charging each metal sheet with a different charge, alpha particles repel the positively charged metal sheet drifting away from the sensitive instrument, consequently its reading decreases.

Answer: The correct choice is ©

self

-			-
1	Test	111-	
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Which of the following are not deflected by the effect of the charged plates?

(a) Cathode rays.

(b) Alpha particles.

© Protons.

d Hydrogen atoms.

Idea of answering:

- : Cathode rays are charged.
- :. The choice (a) is excluded.
- : Each of alpha particles and protons are charged.
- : The choices (b) and (c) are excluded.

Answer: The correct choice is

Questions ?

Chapter

Lesson One

Multiple choice questions (6)





Aristotle's idea			
Who is the scient	ist who believed that i	matter is composed of	water,
dust, air and fire	?		
Bohr.	(b) Rutherford.	© Dalton.	d Aristotle.
The scientist who	rejected the existence	e of atoms is	
a Democritus.	(b) Dalton.	© Aristotle.	d Bohr.
Dalton's model	of the atom		
3 What is the nam	e of the scientist who	was the first to give a t	heory about
the composition	of the atom ?		
a Dalton.	(b) Rutherford.	© Democritus.	d Bohr.
The scientist wh	o hypothesized that th	e compounds are comp	osed of certain
elements combin	ned in a simple numeri	cal ratio is	
a Dalton.	(b) Schrödinger.	© Thomson.	d Bohr.
Each of the follo	wing is among Dalton'	s theory postulates, ex	cept that
a atoms of the e	lements contain protons	s, neutrons and electrons	1.
b the masses of	the atoms of the same e	lement are similar.	
© the atom is inc	livisible.		
d each element i	s formed of tiny particle	es called atoms.	
Which of the follo	owing examples agree	s with Dalton's postula	ites ?
		•	those which are found in
a sample of su	lphur.		
(b) The properties	of the molecules of hyd	drogen and oxygen diffe	er from their properties in
water molecul	es.		
© Hydrogen can	combine with oxygen to	o form water molecule i	in more than one
numerical ratio			
(d) Atoms which f	form magnesium elemei	nt are tiny.	

- The ratio of the number of hydrogen atoms to that of sulphur atoms in hydrogen sulphide molecule is 2:1, this is consistent with one of the postulates of
 - (a) Thomson's theory.

(b) Rutherford's theory.

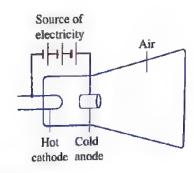
© Bohr's theory.

- (d) Dalton's theory.
- 8 Dalton concurred with Democritus in his idea that
 - (a) the element has no atoms.
 - (b) the compound is formed by the combination of its elements in constant ratios.
 - (c) the atom contains a vast space.
 - (d) the atom is indivisible.

Thomson's model of the atom

- Which of the following cases is a gas that conducts electricity?
 - (a) Hydrogen gas at normal conditions.
 - (b) Neon gas upon its decomposition.
 - © Argon gas under high pressure and low voltage.
 - (d) Chlorine gas under low pressure and high voltage.
- When the potential difference between the two electrodes of a discharge tube reaches around 10000 volts, it is noticed that
 - (a) the electrical conductivity of the gas in the tube decreases.
 - (b) the resistance of the gas in the tube to the electron passage increases.
 - © a flash occurs at the cathode.
 - d a flash occurs on the wall of the discharge tube.
- The apparatus which is illustrated in the opposite figure does not produce cathode rays.

 What is the modification which should be introduced to obtain the rays?
 - (a) Altering the connection of the electrodes of the source of electricity.
 - (b) Heating the anode instead of the cathode.
 - © Using an alternating current source instead of direct current source.
 - d Discharging the air from the tube.



Electric disc	charge experiment of Th	nomson proved that the atom	
a is solid.			
(b) contains	a vast space.		
© contains	a positively charged nuc	leus.	
d contains	negatively charged elect	rons.	
The cathod	e rays consist of very fir	ne particles called	
(a) electrons	s. (b) protons.	\bigcirc α -particles. \bigcirc atoms.	
Cathode ra	ys have		
a mass on	ly.	(b) charge only.	
(c) neither r	nass nor charge.	d mass and charge.	
the proper	ties of the produced ca	•	
Choices	the cathode rays	Effect of an electrical field on these rays	
(3)	The positive cathode	The rays are deviated towards the positive electr	ode
b	The negative anode	The rays are deviated towards the negative elect	rode
<u>©</u>	The positive anode	The rays are deviated towards the negative elect	rode
(d)	The negative cathode	The rays are deviated towards the positive electronic	rode
	the rays	or electric field that affects the tube of the cath (b) travel in straight lines.	ode
	positively charged.	d) do not cause a glow on the tube w	alls.
When a be		lls on a sheet of platinum,	
_	perature does not change	•	nts.
() 123 TO 11	portarare does not onling.	o. O it is bloken down to brian regions	
		heel of mica placed in the path of the cathode r	ays
proves th	at these rays		
a have th	nermal effect.	(b) are negatively charged.	
© are pos	sitively charged.	d have mass and travel in straight li	nes.

1	The term "electro	on" was not known at tl	ne time of the stateme	nt si
	a Rutherford's a	tomic model.	b Bohr's atomic m	ode!
	© Thomson's ato	mic model.	(d) Bohr's modified	atomic mode ¹
2	Which of the follo	wing properties is the s	trong evidence which p	proved that the
	cathode rays exis	t in all materials?		
	(a) They have a the	ermal effect.		
	(b) They move in s	traight lines.		
	© They consist of	very fine particles.		
	d They do not dif	fer either in behavior or	in nature, even if the mat	erial of
	the cathode is	changed.		
21	Particle like chara	ncter of cathode rays is i	indicated by	
	a their ability to	move in straight lines.		
	b their ability to	induce flashes on the sen	sitive plates.	
	© their deviation	when passed in an electr	ic or a magnetic field.	
	d their thermal en	ffect.		
2	2 Electrical neutrali	ty was first mentioned i	in	
	a Democritus's p	erception of matter.	(b) Dalton's atom.	
	© Boyle's concep	t of matter.	d Thomson's atom.	
	Rutherford's mo	del of the atom		
2	The metal sheet u	sed in Rutherford's expe	eriment is lined with a l	ayer of
	a ZnS ₂	\textcircled{b} ZnSO $_3$	© Zn ₂ S	d ZnS
2	The scientist who	used the radioactivity p	ohenomenon in identify	ing the composition
	of the atom is		,	
	(a) Dalton,	(b) Thomson.	© Bohr.	(d) Rutherford.
2	Rutherford's theo	ry proved for the first tir	ne that the atom	,.
	(1) is indivisible.		(b) is electrically neut	
	© contains a vast	space.	(d) is solid.	

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- Which of the following observations shows the invalidity of the claim that the atom is solid, as presumed by both Thomson and Dalton?
 - (a) Deviation of some alpha particles upon collision with the gold foil.
 - (b) Penetration of a small fraction of alpha particles upon collision with the gold foil.
 - (c) Reflection of a small percentage of alpha particles upon collision with the gold foil.
 - d Appearance of flashes on the sensitive plate behind the gold foil after falling of alpha particles on it.
- In the experiment which is illustrated in the opposite figure.

What does the path of the rays (X) indicate?

- (a) The presence of a dense part in the atom and most of the atomic mass is concentrated in it.
- (b) The presence of negatively charged particles revolving around the center of the atom.
- © The presence of the protons inside the atom.
- (d) The atom is not a solid particle.
- In Rutherford's experiment, the deflection of a small fraction of α-particles shows that the atom contains
 - a electrons.
- (b) protons.
- (c) nucleus.
- d neutrons.

Beam of

a - particles

Gold foil

(X)

Metal sheet lined with zinc sulphide

- The gold foil experiment which was carried out in Rutherford's lab
 - (a) confirmed Thomson's atomic theory.
 - **(b)** is the base for Dalton's theory.
 - © led to discovering the nucleus of the atom.
 - d entailed using a source of beta particles.
- Which of the following postulates belongs to Rutherford's model but not to Thomson's ?
 - (a) The atom is a sphere of uniform positive electric charges.
 - (b) The atom contains negatively charged electrons.
 - © The atom contains a positively charged nucleus.
 - d The atom is electrically neutral.

	In Rutherford's	experiment, the ratio	of the number of the per	netrating alpha particl-
	to that of alpha	particles which boun	ced back is	
	a much more th	an 1		
	b less than 1			
	© equal to 1			
	d a little less that	an 1		
3	The scientist who	o designed the first a	tomic model on trial basi	s is
	® Rutherford.	(b) Thomson.	© Bohr.	d Dalton.
3	The scientist who	discovered that the	electrons have negligible	mass compared to
	that of the nucle	us is		
1	a Thomson.	b Bohr.	© Rutherford.	d Dalton.
3	Rutherford's mod	iel of atom		
	(a) is the recently	adopted model of ator	m.	
	(b) assumed that t	he atom is solid.		
	© explained the	unique atomic spectru	m of the different element	s.
	(d) assumed that the	he charge of the electr	ons equals the charge of t	he nucleus.
35	After carrying out	t Rutherford's experi	ment using a foil of gold	and alpha particles.
	All the following	were concluded, exce	<u>ept</u>	
	(a) the small size of	of the nucleus of the a	tom.	
	b the charge of the	he nucleus.		
	© the atomic mas	sses of the elements.		
	d the movement	of the electrons aroun	d the nucleus.	
36	When alpha parti	cles and cathode rays	are exposed to an elect	ric field or
	a magnetic field,	they		
	a move with the	same speed.		
	b pass in opposit	e directions to each ot	her.	
	© pass together in	n the same direction.		
	d are not affected	l by either of them.		

57 Each of the following is passed in an electric field:

(1) Alpha rays.

- (2) Cathode rays.
- (3) A group of the nuclei of the atoms of different elements.

Which of the following expresses the path of each of (1), (2) and (3) in this field?

Choices	(1)	(2)	(3)
(a)	Are deflected towards the positive pole	Take a straight path	Are deflected towards the negative pole
(b)	Are deflected towards the negative pole	Are deflected towards the positive pole	Take a straight path
©	Are deflected towards the negative pole	Are deflected towards the positive pole	Are deflected towards the negative pole
<u>d</u>	Are deflected towards the positive pole	Are deflected towards the positive pole	Are deflected towards the negative pole

38 The failure of Rutherford's atomic model is attributed to that it did not explain

- a the nature of the movement of the electrons around the nucleus.
- (b) the presence of a nucleus in the atom.
- © the presence of attraction forces between the protons and the electrons.
- (d) the presence of space between the nucleus and the electrons.



Give reason for :

- (1) The cathode ray tube must be evacuated to a very low pressure.
- (2) The cathode rays are termed by this term.
- (3) Alpha rays are deviated when exposed to a magnetic or an electric field in a direction opposite to that of the cathode rays.
- (4) The metallic plate in Rutherford's experiment is lined with ZnS
- (5) Rutherford's model of atom resembles the solar system.
- (6) The electron does not fall into the nucleus despite the attraction between them.
- What happens when an amount of a gas is pumped in the tube of the cathode rays?

 Explain.
- In cathode ray experiment, what happens when the platinum electrode (the cathode) is replaced by an electrode of copper? Explain.

In the shown diagram which illustrates Rutherford's experiment:

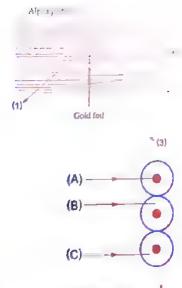
- (1) Why is ray (1) bounced back?
- (2) What is the indication of:
 - (i) The penetration of ray (2) to the gold foil without deviation.
 - (ii) The deviation of ray (3).
- The opposite figure shows Rutherford's experiment.

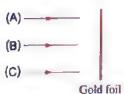
 Which of alpha particles (A, B or C) will flash at the same position before and after placing the gold foil?

 Explain your answer.



- Particle (B): Moves close to the nucleus of the atom of gold.
- Particle (C): Moves in the space surrounding the nucleus of the atom of gold.
- (1) Complete the path of the three particles on the figure.
- (2) Show the importance of using a huge number of α -particles in this experiment.





Higher – order questions

Answered in detail

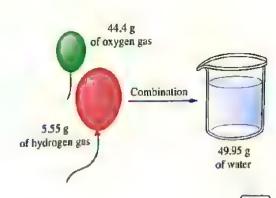
Choose the correct answer:

5 Which of the following facts does not match Dalton's atomic model?

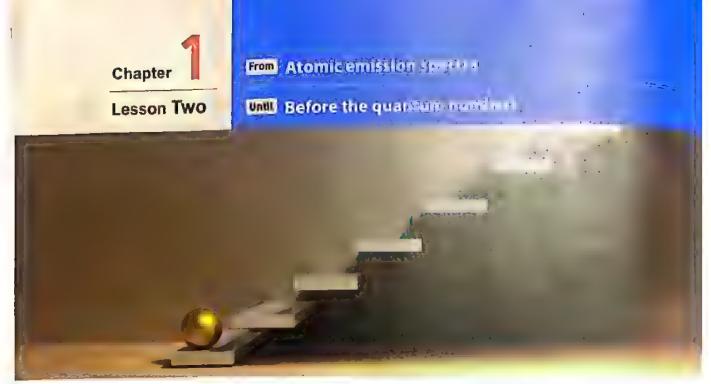
- (a) The mass of each atom of copper atoms equals 63.5 u
- (b) The mass of iron atom differs from that of copper atom.
- (c) Uranium-285 nucleus undergoes fission forming lead.
- d Hydrogen molecule is composed of two atoms.

Essay question:

- The opposite figure represents a postulate of an atomic theory that you have studied:
 - (1) Who did formulate this theory?
 - (2) State the postulate represented by the figure.



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Atomic emission spectra

- On heating atoms of a pure element in gaseous or vapor state to high temperatures or exposing them to a low pressure inside an electrical discharge tube, they emit a radiation called emission spectrum (line spectrum).
- On examining this radiant light by a device called spectroscope, it was found that it is composed of a limited number of restricted colored lines separated by dark areas.
 So, it is called line spectrum.

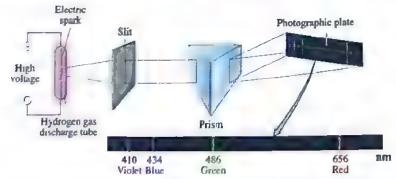
Line spectrum (emission spectrum) is an atomic spectrum composed of limited number of restricted coloured lines separated by dark areas.

• The line spectrum is characteristic for each element .. G.R.?

Because there are no two elements with the same line spectrum, and this is due to the difference in the atomic number (number of protons and so electrons) from one element to another.

Application The line spectrum of hydrogen atom.

* The line spectrum of hydrogen atom appears during examination as four colored lines separated by dark areas, as in the following figure:



Visible line spectrum of hydrogen atom consists of four coloured lines

* It is noteworthy to know that the physicists - at that time - were not able to explain this phenomenon.

Test-Yourself

The line spectrum differs from an element to another due to

- (a) the difference in the number of neutrons in each of them.
- (b) the difference in the mass number of each of them.
- (c) the difference in the electronic configuration of each of them.
- (d) the difference in the number of valence electrons in each of them.

Idea of answering:

Answer: The correct choice is

Bohr's atomic model (1913)

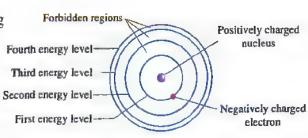
The study of atomic spectra is considered the key which solved the puzzle of the atomic structure. That was achieved by the Danish scientist Niels Bohr upon which he was rewarded the Nobel Prize in 1922



Bohr's postulates

A Points that agree with Rutherford's postulates

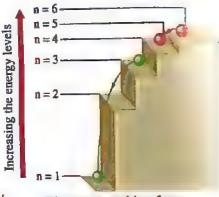
- A positively charged nucleus exists in the center of the atom.
- 2) The number of negative electrons (revolving around the nucleus) equals the number of positive protons inside the nucleus.
- During the revolving of the electron around the nucleus, a centrifugal force arises which is equivalent to the attraction force of the nucleus on the electron.



Bohr's model of atom

B New postulates

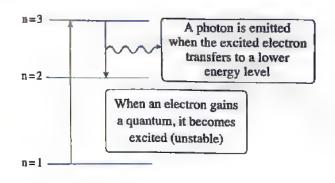
- Electrons orbit the nucleus in a rapid movement without emission or absorption of any amount of energy and the atom in this case is named stable atom.
- Electrons orbit the nucleus in definite allowed energy levels. They cannot be found in the regions between these levels, where the electron moves from an energy level to another one via a complete jump.
- 6 Each electron in the atom has a definite amount of energy depending on the distance between its energy level and the nucleus, the energy of any level increases as its radius increases. Each energy level is expressed by an integer number called the principal quantum number (n), and the electron revolves in the lowest allowed energy level in its ground state.



Electron transition from an energy level to another one takes place via a complete jump

When the electron acquires a quantity of energy - known as quantum - by heating or by electric discharge, the electron jumps temporarily to a higher energy level. This is in case that the absorbed quantum of energy is equal to the difference in energies between the two levels, and the atom in this case is known as "excited atom".

Since the electron in the excited atom
is unstable, it returns back to its original
level with emission of the same quantum of
energy (photon) in the form of radiant light
that appears in the form of a characteristic
visible spectral line of a certain wavelength
and frequency, hence the atom returns to its stable state.

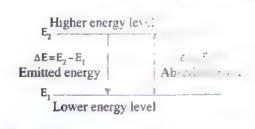


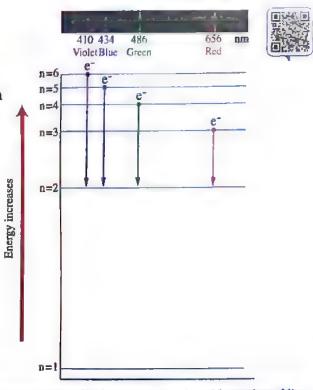
Common mistake Trerere

Presuming that the electron can gain or lose fractions of a quantum $(\frac{1}{4} \text{ quantum or } \frac{1}{2} \text{ quantum})$.

- * The stable atom is the state of the atom when its electrons energy is the least.
- * The excited atom is the state of the atom after gaining a quantum of energy, through heating or electrical discharging.
- * Quantum is a quantity of energy gained or lost when the electron is transferred from an energy level to another energy level.

- The acquired amount of energy (the quantum) when an electron transfers from its ground state to the excited state equals the amount of energy which is released when this electron returns back to its ground state level.
- A lot of atoms absorb different amounts of energy (quanta) in the same time that a lot of excited atoms release other quanta producing spectral lines. These spectral lines indicate the energy levels from which their electrons are transmitted back to the ground state.
- * This explains that the line spectrum of hydrogen atom consists of four coloured lines, where they indicate the higher energy levels from which the electron transfers to the second energy level only.





The visible line spectrum of hydrogen atom consists of four coloured lines (The wavelength of the visible spectrum ranges between 410: 656 nm)

Worked Example

The opposite figure illustrates some travels of the electron of an excited hydrogen atom between the different energy levels.

Which of these travels produces a spectral line of hydrogen atom?



(b) В

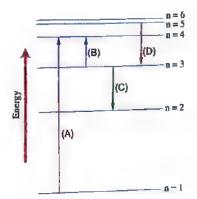
© C

(d) D



The spectral line of hydrogen atom is formed when the excited electron is transferred from higher energy levels to the second energy level only.

Answer: The correct choice is ©



Notes

Bohr's calculations of the radii of the energy levels of hydrogen atom and the energy of each level revealed that:

 The amounts of energy required to transfer an electron between the different energy levels are not equal .. G.R.?

Because the distance and the difference in energy between them are not equal.

 The quantum required to transfer an electron from an energy level to another decreases as we go farther from the nucleus .. G.R.?

Because the energy gap (between energy levels) decreases as we go farther from the nucleus.



Transference of an electron between two close energy levels



Transference of an electron between two distant energy levels

Test-Yourself

What does happen to the spaces between energy levels on moving from (n = 1) to (n = 7)?

- (a) Decrease by increasing (n).
- (b) Do not change.
- © Increase by increasing (n).
- d Change irregularly.

Answer: The correct choice is

Worked Example

Which of the following transfers of the electron of hydrogen atom is accompanied by releasing the largest amount of energy?

(a)
$$n = 3 \longrightarrow n = 2$$

(b)
$$n = 5 - n = 4$$

$$\bigcirc$$
 n = 2 \longrightarrow n = 1

Idea of answering:

- The difference in energy (the energy gap) between two consecutive energy leveldecreases as the distance from the nucleus increases.
- :. The difference in energy between the second energy level (n = 2) and the first energy level (n = 1) is the highest.

Answer: The correct choice is (c)

The advantages and drawbacks of Bohr's atomic model

Despite the great efforts of Bohr to formulate his atomic model, the quantitative calculations of his theory didn't match all the experimental results.

Advantages (success) of Bohr's atomic model:

- 1 It explained the hydrogen spectral lines.
- It introduced the idea of quantized energy (for the first time) to determine the electron energy in different energy levels in the atom.

Drawbacks of Bohr's atomic model:

The most important defects of Bohr's theory were the following:

- 1 It failed to explain the spectrum of any other element, (not even helium atom which contains 2 electrons only), except hydrogen atom which is the simplest electronic system, where it contains one electron only.
- 1 It considered the electron as a negative charged particle only and ignored its wave properties.
- It presumed that it is possible to determine precisely both the location and speed of an electron at the same time, but in fact this is experimentally impossible.
- O It described the electron as a particle moving in a circular planar orbit, this means that hydrogen atom is planar. Later on, it was proved that the hydrogen atom has three dimensional coordinates.

The principles of modern atomic theory (modified Bohr is model)

The modern atomic theory is based on some essential modifications of Bohr's model.

Among the most important modifications are:

- A The dual nature of electron.
- Heisenberg's uncertainty principle.
- The wave-mechanical theory of the atom.

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The dual nature of electron

All the previously mentioned theories considered the electron just as a tiny negatively charged particle. However, all experimental data showed that the electron has a dual nature .. G.R.?

As it is a material particle which also has wave properties.

The dual nature of electron

The electron is a material particle which has wave properties.





B Heisenberg's uncertainty principle

Bohr's theory presumed that it is possible to determine both the location and velocity of the electron precisely at the same time, but by applying the principles of quantum mechanics, Heisenberg concluded that

"The determination of both the speed and position of an electron at the same time is practically impossible.

So, speaking in terms of "probability" seems to be more precise".

This is because the electron wave motion doesn't have a certain position.

Heisenberg's uncertainty principle

The determination of both the velocity and position of an electron at the same time is practically impossible and this is subjected to the laws of probability.



The wave-mechanical theory of the atom

The Austrian scientist Schrödinger (1926) applied the ideas of Planck, Einstein, De Broglie and Heisenberg, and could:

- Establish the wave-mechanical theory of the atom.
- Derive a wave equation that could be applied to the electron movement in the atom.

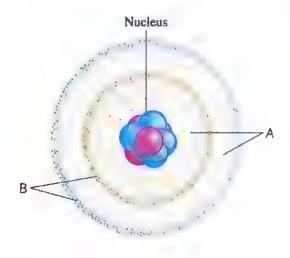
On solving Schrödinger's equation, it is possible to:

- Determine the allowed energy levels.
- 2 Define the regions of space around the nucleus, where it is most probable to find the electron in each energy level.



Heisenberg

• The wave-mechanical theory changed our concept about the movement of electrical where instead of speaking about the regions between the fixed circular orbits as being completely forbidden for the electrons, this theory introduced the concepts of:



Electron cloud

It is the region of space around the nucleus, in which the electron probably exists in all directions and distances (dimensions) (region A).

Orbital

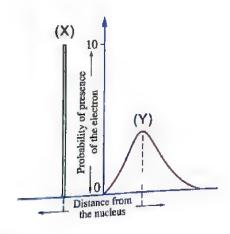
It is the region within the electron cloud which has high probability of finding the electron (region B).

Worked Example

What does each of (X) and (Y) represent in the opposite figure ?

Idea of answering:

- : (X) indicates a definite level around the nucleus in which the electron can be found.
- · (X) represents an orbit.
- : (Y) indicates a high probability of finding the electron.
- · (Y) represents an orbital.



(E)
400
<u>-</u>
40
-
-

Atomic model	i Dalton's	Thomson's	Rutherford's	Bohr's	Modern atomic theory
Atom	* Solid indivisible particle. * Masses of the atoms of the same element are similar, but they differ from one element to another.	* Solid sphere of uniform positive electric charges in which a number of negatively charged electrons are embedded resulting in making the atom neutral.	* Contains a vast space (not solid).	* Contains a vast space (not solid). * Electrically neutral. * Planar.	* Contains a vast space (not solid). * Electrically neutral.
Nucleus	Was not mentioned yet	Was not mentioned yet	* Positively charged. * Much smaller than the atom. * Most of the mass of the atom is contained in it.	* Positively charged. * Much smaller than the atom. * Most of the mass of the atom is contained in it.	* Positively charged. * Much smaller than the atom. * Most of the mass of the atom is contained in it.
Electrons	Were not mentioned yet	* Negatively charged particles embedded in the atom.	ive ind	* Negatively charged material particles (no wave properties yet). * They orbit the nucleus in definite orbits, and can not be found in the spaces between these orbits (forbidden regions). * The energy of the electron increases as the distance from the nucleus (the radius of its energy level) increases. * When an electron gains a quantum of energy, it jumps to a higher energy level, and the stable atom becomes excited.	* Material particles having wave properties (Dual nature of the electron). * It is not possible practically to determine both the velocity of an electron and its position at the same time, so this is described as probability distribution (uncertainty principle). * The region around the nucleus in which the electron probably exists in all dimensions is called the electron cloud. * The three dimensional region of space that indicates where there is a high probability of finding an electron is known as the orbital.
Additional information	The atoms of the different elements combine with each other in simple numerical ratios forming the compounds.		* This theory could not elucidate the system of revolving the electrons around the nucleus.	This theory could not explain the line spectrum of any element atom other than hydrogen atom.	

Multiple chains questions





Atomic emission spectra (Line spectra)

© emit gamma rays. The line spectrum of an element is charathe same	(b) atomic mass. (d) physical properties. I led to concluding the electron configuration
the same	(b) atomic mass. (d) physical properties. I led to concluding the electron configuration
a) atomic number. c) physical state. What is the scientific contribution which of the elements? a) Boyle's perception of the element. b) Analyzing the light emitted from the atc) c) Thomson's atomic model.	d physical properties. I led to concluding the electron configuration
© physical state. What is the scientific contribution which of the elements? Boyle's perception of the element. Analyzing the light emitted from the at Thomson's atomic model.	d physical properties. I led to concluding the electron configuration
What is the scientific contribution which of the elements? a Boyle's perception of the element. b Analyzing the light emitted from the at Thomson's atomic model.	led to concluding the electron configuration
a Boyle's perception of the element. b Analyzing the light emitted from the at Thomson's atomic model.	led to concluding the electron configuration comes when they acquire energy.
a Boyle's perception of the element.b Analyzing the light emitted from the atc Thomson's atomic model.	coms when they acquire energy.
b Analyzing the light emitted from the at Thomson's atomic model.	coms when they acquire energy.
© Thomson's atomic model.	coms when they acquire energy.
d Rutherford's atomic model.	
All the following are correct, except	
a) the line spectrum of hydrogen atom is f	formed of four inseparable colours.
b) electrons have dual nature.	
Bohr's atomic model introduced the co	ncept of quantum to determine the energy
of the electrons.	
d) in case of not gaining or losing energy,	the atom is described to be stable.
Bohr's atomic model	
Yho are the two scientists who agreed c	on the idea that most of the atom is empty
pace ?	
Geiger and Democritus.	(b) Boyle and Dalton.
Thomson and Bohr.	(d) Rutherford and Bohr.

6	According to Bohr's theory, the orbit in W	hich the electron revolves can be
1	determined through	
	(a) the electron mass.	(b) the electron energy.
	© the electron charge.	d the nucleus charge.
7	Through studying the line spectrum of an	atom, it is possible to know
	(a) the isotopes of the element atom.	
	(b) the energy levels in the atom.	
	© the composition of the nucleus of the at	om.
	d the number of the neutrons inside the n	ucleus of the atom.
8	When an electron absorbs a quantum, it	will transfer to
	all higher energy levels.	
	(b) all lower energy levels.	
	© a higher energy level that matches the	absorbed quantum.
	d a lower energy level that matches the	
1	When the electrons of an excited atom	return to their original energy levels,
	this results in the emission of	-
	α-particles.	b β-particles.
	c energy in the form of line spectra.	④ γ-rays.
1	Each of the following is correct for the	electron, except
		absorbs energy to travel to a higher energy level.
		d from the excited electron equals the amount of
		e electron to reach this certain state of excitement.
		an be at infinite distance from the nucleus.
	d electron can absorb different quanta of	or energy.
E	The excited electron tends to	
	(a) absorb energy to return to its ground	
	(b) produce light with a definite wavelen	gth and energy.
	© stay in its unstable state.	
	(d) settle in a higher energy level.	
1		the non-luminous region of bunsen flame,
	•	by that the electrons in the excited atoms of
	lithium	O sti
	(a) are lost from the atoms.	(b) their number increases.(d) transfer to higher levels.
	© return to the ground state.	transier to ingher levers.

	in the excited state, it is				
	a in the second energy level.	(b) in th	e nucleus.		
	© closer to the nucleus.	d farth	er from the nuc	deus.	
1	Which of the following supports the conce	ept of qua	ntum in deterr	nining the en	ergy
1	of the electrons ?				
	(a) The emission spectrum of hydrogen atom	1.			
	(b) The cathode rays.				
	\bigcirc The deflection of some α -particles upon			-4	
	① The penetration of most of α-particles up	on collision	on with gold for	il.	
Œ	According to Bohr's atomic model, to trave	el from th	e first level K	to	
	the fourth level N, the electron				
	a acquires a quantum.		a quantum.		
	© acquires 4 quanta.	(d) loses	4 quanta.		
16	To obtain the visible spectrum of hydroger	n atom for	an electron th	iat has been e	excited
	to the energy level \mathbf{M} , this electron must .				
	a lose a quantum of energy less than that it				
	b gain a quantum of energy greater than that		ined.		
	© lose the quantum of energy it has already	gained.			
	d gain quantum of energy.				
7	The visible line spectrum of hydrogen atom	n arises as	a result of the	e return of	
	the excited electron from higher energy lev	vels to the	level	14	
	ⓐ K ⓑ L	© M		(d) N	
8	Which of the following transitions of the el	ectron in	hyd <mark>rogen</mark> ator	n results in	
	the emission of visible light?				
	(a) $(n = 5) \longrightarrow (n = 2)$.	b $(n = 3)$	(n = 1)).	
	© $(n = 5)$ — $(n = 3)$.	(\mathbf{d}) ($\mathbf{n} = 6$	(n = 3)).	
9	The opposite figure shows several travels of	of		A B C	D
	the electron of an excited hydrogen atom		n=4 n=3	A B C	
	between different energy levels.		n=2		
	Which of these travels produces a spectral	line			
	of hydrogen atom ?				
	(a) A	(p) B			
	⊙c	(d) D	n=1	<u> </u>	
			ت (شرح) / ۲۵ (م : ه)	المنام كسيام الخان	33
			ت (شرح) ۱۱ت (م : ۵)	ene same home	

(3) On comparing the position of an electron in its ground state, with its position

20 Each line in the line spectrum of lithium atom represents

- (a) the energy absorbed by the atom when it loses an electron.
- b) the energy absorbed by the atom when it gains an electron.
- c the energy released when an electron transfers from a lower energy level to a higher energy level.
- (1) the energy released when an electron transfers from a higher energy level to a lower energy level.

1 The spectral lines of the atom of any element indicate

- (a) the number of electrons in the atom of this element.
- b) the energy of the level where the electron is present.
- © the energy of the electron in the energy level.
- d the difference in energy between two energy levels.

22 The radiation whose wavelength is 486 nm lies in the region of

(a) infrared rays.

(b) UV rays.

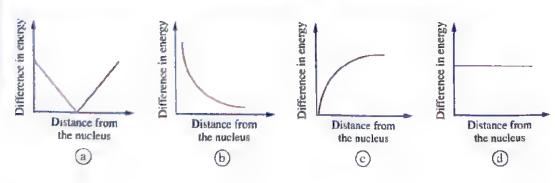
© visible rays.

d infraviolet rays.

The electron in hydrogen atom which is excited to the fourth energy level

- a remains in the same new energy level.
- (b) returns to its ground state accompanied by visible spectrum only.
- © returns to its ground state in one jump or several successive jumps.
- d transfers to a higher energy level.

What is the chart which represents the relation between the difference in energy between two consecutive levels in an atom and the distance from the nucleus?



- (a) electrons can acquire any amount of energy.
- (b) it is impossible to determine the path of the electrons precisely.
- c) the energies of the electrons in different energy levels are determined through the concept of quantum.
- (d) the electron has a dual nature.

Which of the following statements is consistent with Bohr's postulates?

- (a) Space regions between energy levels are occupied by electrons.
- b The atom has no dimensions or spatial directions.
- (c) The electron is a negative particle with wave properties.
- (d) The electron revolves around the nucleus in all directions.

The dual nature of the electron means that it has

- (a) a mass and a charge.
- (b) a mass and a wave motion.
- (c) a volume and a wave motion.
- d a mass and a density.

Bohr's atomic model differs from that of Rutherford, this difference is obvious in Bohr's postulate that the electron

- a produces a spectral line when it loses a quantum.
- b) is a negatively charged particle.
- © does not produce a spectral line when it loses a quantum.
- (d) revolves around the nucleus in certain orbits.

The modern atomic theory

Which of the following electronic transitions in hydrogen atom is accompanied by releasing the largest amount of energy?

- (a) From the orbit M to the orbit L and the position of this electron can be determined.
- (b) From the orbit N to the orbit M and neither the position nor the speed of this electron can be determined precisely.
- © From the orbit L to the orbit K and this electron has a dual nature.
- d From the orbit L to the orbit K and the position and the speed of this electron can be determined precisely.

Atomic Structure

30	Each of the following is	among the properties	of the electron, exce	pt that it	
1	a is a material particle.				
	b has wave properties.				
	© loses energy when it	transfers from one ene	ergy level to a higher le	evel.	
	d is deflected by the ef	fect of a magnetic field	d.		
1	A drawback of Bohr's n	nodel that was fixed by	y the modern atomic t	heory is that	
	a the electron has a du	ial nature.			
	b) the electron has a w	ave nature.			
	c the electron is a negatively charged material particle.				
	d the electron revolve	es around the nucleus in	electron cloud.		
3	The scientist who pres	sumed that it is possib	le to determine both t	he speed and position	
	of an electron togeth	er precisely is			
	(a) Heisenberg.	(b) Thomson.	© Bohr.	d Boyle.	
8	What is the name of	the scientist who dest	royed Bohr's belief the	at there are regions in	
	the atom forbidden	or the electrons?			
	a Boyle.	(b) Heisenberg.	© Schrödinger.	d De Broglie.	
6	Which of the followi	ng statements is a Hei	senberg's modificatio	n to Bohr's	
	atomic model ?				
	a It is difficult to de	termine the position an	d the speed of the elect	ron together precisely.	
	(b) Space regions between	ween energy levels are	not forbidden for the e	lectrons.	
	© The electron is a particle with wave properties.				
	d Both the speed an	d the position of the ele	ectron can be determine	ed together precisely.	
8	The actual position	of the last electron in	n iron atom and its sp	eed in a certain	
	moment can not be	precisely determined	1" .		
	The previous state	ment is an application	of		
	ⓐ Hund's rule.		(b) Bohr's model.		
	© uncertainty princi	ple.	d the dual nature	of the electron.	
3	According to the wa	ve-mechanical theory	,		
	a the electron has a	mass as well as wave	properties.		
	b the electrons are f	ound in the orbitals.			
	© the nucleus is ver	y small compared to the	ne atom.		
	d the electrons are	negatively charged.			



Applying the wave equation to the last electron in lithium 3Li atom shows that

- (a) its location can be determined precisely in the energy level L
- (b) it moves towards or away from the nucleus in the energy level L
- © its energy is lower than the energy of the electrons of the level K
- (d) it moves to the level K after losing a quantum of energy.

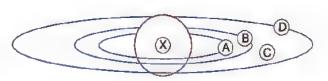
🚺 The modern atomic theory agrees with Rutherford's model on that

- a) the atom is not solid.
- b the electrons have wave properties.
- c) it is impossible to determine the speed and the position of the electron together precisely.
- d there is a pattern according to which the electrons orbit the nucleus.

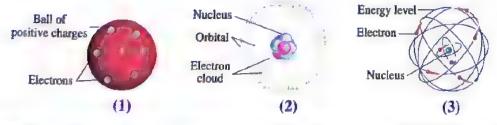


💯 Give reason for :

- (1) The emission spectrum is known as line spectrum.
- (2) The line spectrum is a defining characteristic for each element.
- (3) The quantum of energy required for the travelling of an electron between different energy levels is not a constant quantity.
- (4) The incorrectness of Bohr's assumption that hydrogen atom is planar.
- (5) The electron has dual nature.
- In the opposite figure, determine
 with explanation the position(s)
 in which the electron can not be present
 according to Bohr's atomic model.



The figures below illustrate 3 different atomic models:



Arrange these figures ascendingly according to the development of the concept of the composition of the atom.

- Trapter 1
- The following statements represent the attempts to develop the atomic mode' no particular order:
 - (A): The electron has wave properties in addition to its particle nature.
 - (B): The atom contains tiny negatively charged particles.
 - (C): In the center of the atom, a small nucleus is found which is of high density.
 - (D): The atom is solid and indivisible.

What is the correct sequence of these attempts?

- In the light of your understanding for Bohr's atomic model.

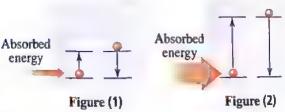
 Show the change which occurs in each of the energy and the position of an electron when it is excited.
- The opposite table represents the probabilities of the emission spectrum of hydrogen atom.

 Which of these probabilities represents the visible spectrum of hydrogen atom?

 Give reason.

Probability	Electron transfer	
	From (n)	To (n)
(A)	2, 3, 4, 5	1
(B)	3, 4, 5, 6	2
(C)	4, 5, 6, 7	3

the emission of the green light and
the red light - with no particular order as a result of the returning of an excited
electron to its ground state in hydrogen atom.
Which of them represents the green light?



The two opposite figures represent two different perceptions for the movement of the electrons around the nucleus, predict :



- The name of the scientist who suggested the perception which is illustrated in the figure (Y).
- (2) The scientific term that represents the region in which the electron can be found in the figure (X).

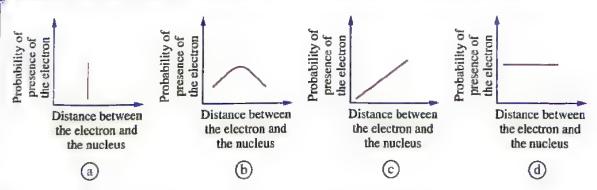
Explain.

Choose the correct answer:

The visible line spectrum of hydrogen atom consists of four coloured lines.

Which of them has the smallest frequency?

- a) The green.
- (b) The blue.
- © The red.
- d The violet.
- Which of the following graphical figures represents Bohr's concept of the orbit?



In an excited hydrogen atom, a photon of light with wavelength 486 nm is emitted when the electron transfers from the principal level (n = 4) to the principal level

$$a$$
 $n = 1$

(b)
$$n = 2$$

$$\bigcirc$$
 n = 3

$$\bigcirc$$
 n = 5

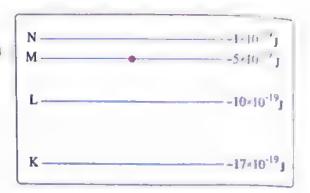
- - (a) higher than ΔE_1
 - **b** lower than ΔE_1
 - © equal to ΔE_1
 - d approximately equal to ΔE_1

Atomic Structure

- If an electron acquires an amount of energy equals 1.89 eV to transfer from entitle level L to M, then to transfer from L to K, it may
 - (a) lose an amount of energy equals 1.89 eV
 - (b) acquire an amount of energy equals 1.89 eV
 - © lose an amount of energy equals 10.2 eV
 - d acquire an amount of energy equals 10.2 eV
- In the opposite figure, if an electron in the energy level M in a hypothetical atom acquires an amount of energy equals 3×10^{-19} J, then it



- (b) transfers to the level K
- (c) transfers to the level N
- (d) remains in the level M



Essay question:

Which is greater — with explanation — the frequency of light or the frequency of infrared radiation?

on the First month

Choose the correct answer for the questions	1:	9
---	----	---

- Which of the following represents the rays that are produced from the discharge tabe under high voltage?
 - (a) They are deflected away from negative plate.
 - (b) They are not deflected by the magnetic field.
 - (c) They are positively charged.
 - d) They are striking the cathode.
- Which of the following transitions of the electron of hydrogen atom results in the emission of visible line spectrum with the highest frequency?

(a)
$$(n = 6) \longrightarrow (n = 2)$$

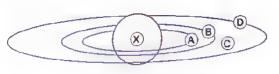
(b)
$$(n = 3) \longrightarrow (n = 4)$$

$$(c)$$
 $(n = 5) \longrightarrow (n = 1)$

(d)
$$(n = 3) \longrightarrow (n = 2)$$

- 3) In Rutherford's experiment, very small fraction of the positively charged particles
 - (a) were slightly deflected as they passed through the metal.
 - (b) passed straight through the metal.
 - © were reflected back from the metal.
 - (d) combined with the metal.
- Which of the following facts doesn't match Dalton's atomic theory?
 - (a) Any matter is made up of small particles which are called atoms.
 - (b) Atoms are not divided in chemical reactions.
 - © Atoms of the same element are chemically alike.
 - d All atoms of same element have the same mass.
- 5) In the opposite figure:

What is the position in which is impossible for the electron to be present (according to Bohr's theory)?



(A)

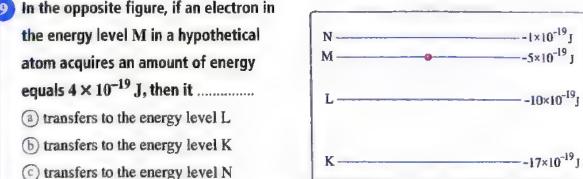
(b) (B)

(C)

(d) (D)

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The modern atomic theory agrees with Rutherford's atomic model on (a) the system in which the electrons revolve around the nucleus. (b) that the electron has dual nature. (c) the impossibility of determination both the speed and the location of the electron together precisely. (d) that the atom is not uniformly dense. The scientist who presumed that it is most probable to find the electrons in the orbitals is (a) Bohr. (b) Rutherford. (c) Thomson. (d) Schrödinger. 8 The electrons of an atom have the lowest possible energies, when the atom is in (a) excited state. (b) inert state. (d) radiation-emitting state. © ground state.



Answer the essay questions 10: 12

Discuss the role of the scientist Schrödinger in explaining the atomic structure.

	us speed desp		etrons travel a			
at a tremendo	us speed desp	ite tile mutus	u attraction oc	tweell fliell a	no the macieu	7
	!*****			*************		
			********************	*********************	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	1 * 1 * 4 *
	*************		.,			
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explain briefi	y the role of z	anc suipmae	in Kutherford	s goid foll ex	periment.	

Test 2

on the First month



Education zone

_	Choose the correct answer for the questions 11: 9
1	To get visible spectrum of the hydrogen atom of an electron excited to the third
	energy level (M), this electron must
	(a) lose a quantum lower than that gained.
İ	b lose a quantum which is gained.
	© gain a quantum.
	d lose a quantum higher than that gained.
2	By applying the wave equation to the last electron in sodium atom 11Na
	it's found that
	(a) it is possible to determine its position accurately in the energy level M
	(b) it moves nearer and farther from the nucleus in the energy level M
	© its energy is less than that energy of the electrons in the energy level L
	d it transfers to the energy level L by losing a quantum of energy.
3	Each atom of hydrogen and helium contains one energy level.
	Which of the following choices is correct?
	(a) They are different in the atomic emission spectrum.
	(b) They are equal in the number of electrons in each of them.
	© They are different in the principal quantum number.
	d They are similar in the atomic emission spectrum.
4	What is the drawback of Bohr's model which was modified by the modern atomic
	theory?
	(a) The electron has wave nature only.
	(b) The electron is a negative charged particle only.
	© The electron orbits the nucleus in certain orbitals.
	d The electron has dual nature.
(5)	The study of atomic spectra is considered the key by which we knew
12	(a) that the electrons are negatively charged. (b) that the atom has a nucleus.
	© the energy levels in the atom.



Which of the following transfers of the electron in hydrogen atom produces a photon with the lowest wavelength ?

(a)
$$(n = 3) \longrightarrow (n = 2)$$

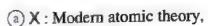
(b)
$$(n = 4) \longrightarrow (n = 3)$$

$$\bigcirc$$
 $(n=4)$ \longrightarrow $(n=1)$

(d)
$$(n = 3) \longrightarrow (n = 1)$$

- The experiment which showed the existence of very fine negatively charged particles in any atom is
 - (a) the cathode-ray tube experiment, explained by Dalton.
 - (b) the gold foil experiment, explained by Thomson.
 - © the gold foil experiment, explained by Rutherford.
 - (d) the cathode-ray tube experiment, explained by Thomson.
- 8 The opposite figures describe two different perceptions for the movement of electrons around the nucleus.

What is the theory which explained each of them?

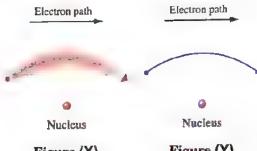


Y: Rutherford's atomic theory.

(b) X: Bohr's atomic theory,

Y: Modern atomic theory.

- © X: Modern atomic theory, Y: Bohr's atomic theory.
- (d) X: Bohr's atomic theory, Y: Rutherford's atomic theory.
- Which of the following does not match Dalton's atomic model?
 - (a) Atoms of the same element are identical.
 - (b) Atoms can be divided into smaller parts.
 - © Atoms of different elements can chemically combine to form compounds.
 - d Atoms of an element are impossible to transform into atoms of another element.



Answer the essay questions 10: 12

10	Illustrate two of the drawbacks of Bohr's atomic model.	
	,	
		** ,

Compare between the orbit according to Bohr's atomic model and the orbital
according to the modern atomic theory.

12	Give reason Rutherford deduced that most of the atom is space.

Test 3 on the First month



Educational zone

Choose the correct answer for the		
Dalton and Thomson agreed on the		
a has no spaces within it.	(b) is electrically neutral.	
© contains negative electrons.	d is homogeneous sphere.	
Which of the following are not defl	lected by the effect of the charged plates?	
(a) Cathode rays.	(b) Alpha particles.	
© Protons.	d Hydrogen atoms.	
According to Bohr's atomic model,	to travel from the first level (K) to	
the fourth level (N), the electron	***************************************	
a acquires a quantum.	b loses a quantum.	
© acquires four quanta.	d loses four quanta.	
The visible line spectrum of hydrog	gen atom arises as a result of the return of	
the excited electron from higher er		
(a) K (b) L	© M	
If the difference in energy between	n energy level (K) and (L) is ΔE_1 then	
the difference in energy ΔE_2 between	een energy levels (O) and (P) is	
a higher than ΔE ₁	b lower than ΔE_1	
© equal to ΔE_1	(d) approximately ΔE_1	
The modern atomic theory agree w	rith Rutherford's model on	
(a) that the atom is not solid.		
(b) that the electrons have wave prop	perties.	
(c) that it's impossible to determine th	ne speed and position of the electron together pre	cisel
d the pattern according to which the	e electrons orbit the nucleus.	
Which of the following cases is a ga	as that conducts electricity ?	
(a) Hydrogen gas at normal condition		
b Neon gas upon its decomposition		
© Argon gas under high pressure an		

- - (a) Thomson's theory.

(b) Rutherford's theory.

© Bohr's theory.

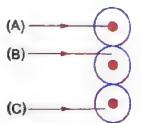
- d Dalton's theory.
- What does happen to the spaces between energy levels on moving from (n = 1) to (n = 7)?
 - (a) Decrease by increasing (n).
 - (b) Don't change.
 - © Increase by increasing (n).
 - d) Change irregularly.

Answer the essay questions 10: 12

The opposite figure shows Rutherford's experiment.

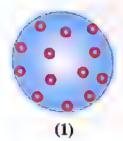
Which of alpha particles (A, B or C) will flash at the same position before and after placing the gold foil?

Explain your answer.



The opposite figures represent two attempts to explain the atomic structure.

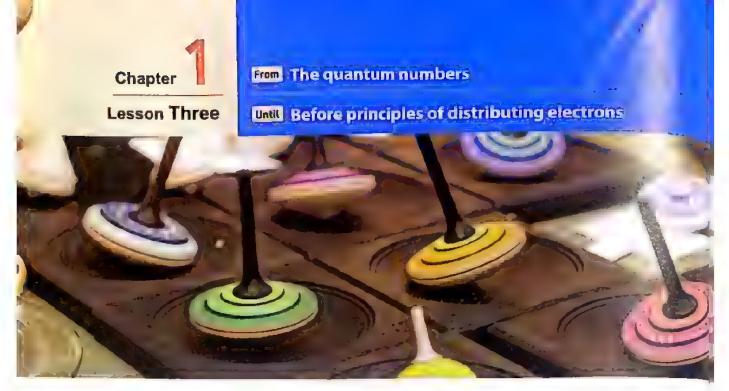
What is the name of the theory that each figure represents?





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two different perceptions for the movement of the electrons around the nucleus.	Figure (X)	Figure (
(1) What is the name of scientist who		
suggested the perception which is		
illustrated in figure (Y)?		
(2) What is the scientific term that repres	ents the region in which t	he electron can be
found in the figure (X)?		



Quantum numbers

The mathematical solution of Schrödinger's equation introduced four numbers that were called quantum numbers.

To determine the energy of an electron in multi-electron atoms, we should know the four quantum numbers which describe it, these four quantum numbers are:

- 1 The principal quantum number (n):

 It describes the distance of the electron from the nucleus.
- The subsidiary quantum number (!):

 It describes the shapes of electron cloud in the sublevels.
- 1 The magnetic quantum number (m_l) :

 It describes the shape and number of the orbital in which the electron exists.
- The spin quantum number (m_s):
 It describes the spin motion of the electron.

The principal quantum number (n)

- It is used to define the following:
 - * The order of principal energy levels or electron shells «Their number in the heaviest known atom in its ground state is seven».
 - * The number of electrons (e) required to fill a given principal energy level from the relation 2n²
 - (i.e. it equals two times the square of the shell number indicated by the letter "n").

Order of the level	The number of electrons required to full (2)
(n)	(211)
1	$2 \times 1^2 = 2$ electrons
2	$2 \times 2^2 = 8$ electrons
3	$2 \times 3^2 = 18$ electrons
4	$2 \times 4^2 = 32$ electrons

G.R. The rule $2n^2$ isn't applied to the energy levels higher than the fourth level.

Because the atom becomes unstable if the number of the electrons which occupy the energy level exceeds 32 electrons.

• The principal quantum number has a positive integer numerical values 1, 2, 3, 4,, (excluding zero). Each value is expressed by an alphabetical letter that represents a principal energy level as shown in the following table:

Number of the level (n)	1	2	3	4	5	6	7
Symbol of the level	K	L	M	N	0	P	Q

Energy of the level increases from K to Q

The subsidiary quantum number (/)

- It determines the energy sublevels within each principal energy level.
- Real energy levels in the atom are called energy sublevels.
- Each principal energy level consists of a number of energy sublevels which are represented by whole numerical values which range between [0 : (n-1)], and their number equals its principal quantum number.
- The energy sublevels take the symbols and values as shown in the following table:

Subsidiary quantum number (l) values $[0:(n-1)]$	0	1	2	3
Symbols of sublevels	S	p	d	f

The following table shows the relation between the principal quantum number n for each energy level and the number of the possible values of the subsidiary quantum number (l), where [n) value = The number of (l) values [n]:

qualitatii oi qualitatii qua	bsidiary antum aber (()
K 1————————————————————————————————————	0
$L \qquad 2 - 2s$	0
	1
n=1	0
M = 3	1
n=3	2
	0
Energy sublevels in each principal energy level N 4	1
	2
-4f	3

- * It is observed that there is a small difference in the energy of the sublevels in each principal energy level.
- * They can be arranged according to increasing their energy in the following order:

$$s$$

Worked Example

What are the probable (ℓ) values when (n = 4)?

- (a) 0 or 1 or 3
- ⓑ 0 or 3 or 4
- © 0 or 1 or 2 or 3
- (d) 0 or 2 or 3 or 4

idea of answering:

- : Each principal energy level consists of a number of sublevels which equals its numerical value.
- \therefore No. of the sublevels = 4
- :. The choices (a) and (b) are excluded.
- : The probable (l) values range between [0:(n-1)].
- :. The probable (1) values when (n = 4) range between [0: (4-1)] = 0 or 1 or 2 or 3

Answer: The correct choice is ©

Test Yourself

Which of the following energy sublevels does not actually exist?

- (a) 2p
- (b) 3d
- © 5d
- (d) 3f

Answer: The correct choice is

The magnetic quantum number (m)

- It determines the number of the orbitals in each principal energy level from the relation: (n²)
- It determines the number of orbitals within a certain energy sublevel from the relation: (2l + 1).
- It determines the spatial orientations (directions in space) of the different orbitals.
- * It is represented by odd numbers of integer numerical values ranging between (-l, ..., 0, ..., +l).

The following table shows the relation between (l) values and the probable values of the magnetic quantum number (m_l) for the electrons of the first four energy levels:

Values of principal quantum number (n)	Values of subsidiary quantum number (l) [0:(n-1)]	Symbols of energy sublevels	Values of the magnetic quantum number (m_{ℓ}) $(-\ell,, \theta,, +\ell)$	Number of the sublevel orbitals $(2\ell+1)$	Number of the principal level orbitals (n ²)
ı	0	Is	0	1	1
	0	2s	0	1	4
2	1	2 <i>p</i>	_1,0,+1	3	4
	0	3s	0	1	
3	1	3р	-1,0,+1	3	9
	2	3d	-2 -1 -0 -+1 -+2	5	
	0	4s	0	1	
4	1	4p	-1,0,+1	3	16
4	2	4d	-2 -1 -0 -1 -1	5	40
	3	4f	_3, _2, _1, _0, _+1, _+2, _+3	7	

No.

Test Yourself

① What are the probable (m_l) values when (l=2)?

- a 0, +1 and +2 only.
- \bigcirc 0, -1 and -2 only.
- \bigcirc -2, -1, 0, +1 and +2
- (d) -3, -2, -1, 0, +1, +2 and +3

Idea of answering:

- : The probable (m_l) values range between -l , , 0 , , + l
- : The probable (m_l) values when (l = 2) are

Answer: The correct choice is

Which of the following possibilities of quantum numbers of an electron includes

a mistake?

(a)
$$n = 3$$
, $l = 2$, $m_l = -1$

ⓑ
$$n = 4$$
, $l = 3$, $m_l = -2$

©
$$n = 1$$
, $l = 1$, $m_l = +1$

(d)
$$n = 2$$
, $l = 0$, $m_l = 0$

Idea of answering:

When (n = 1), then the value of each of (ℓ) and (m_{ℓ}) will be only.

Answer: The correct choice is

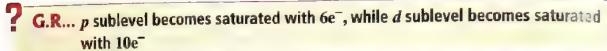
* The orbitals of the same sublevel are equal in energy and similar in shape, but difference, direction in space as shown in the following table:

Sublevels	Number of orbitals	Shape in space (electron density)	Figure
s	1	Spherical symmetrical shape around the nucleus.	Orbital Is Orbital 2s
p	3	 Each orbital takes the form of two pears meeting head to head (dumb-bell shaped) at a point of zero electron density (node). Each orbital is perpendicular to the two other orbitals. The axes of the three orbitals take the three spatial orientations, thus they are designated as p_x, p_y and p_z 	Orbital p_x Orbital p_y Orbital p_z
d	5	Complice	ted shapes
f	7	Complicated shapes	

• Any orbital cannot be occupied by more than two electrons 2e⁻, each of them rotates (spins) around its own axis while revolving around the nucleus (like the earth which spins around its own axis while revolving around the sun).

Each orbital is filled with 2 electrons:

Sublevel	S	p	d	f
Number of orbitals	1	3	5	7
Electron capacity	2	6	10	14



Because p sublevel contains 3 orbitals, while d sublevel contains 5 orbitals and each orbital is filled completely with 2e

and the same			-	700	
100	Worl	1000			
100	TO THE	SC COL	-0.60		E-5"
District Co.				ALC: UNKNOWN	

The orbitals in the same sublevel are different in	
--	--

- (a) the distance from the nucleus.
- (b) the magnetic quantum number.

(c) shape and size.

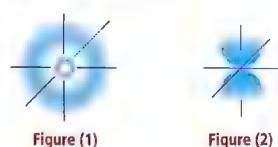
d the subsidiary quantum number.

Idea of answering: -

- The orbitals in the same sublevel have the same principal quantum number.
- .. They are at the same distance from the nucleus.
- .. The choice (a) is excluded.
- The values of the magnetic quantum number (m_l) of the orbitals in the same sublevel range between (-l, ..., 0, ..., +l)
- .. The orbitals in the same sublevel are different in the magnetic quantum number.

Answer: The correct choice is (b)

The following figures illustrate the probable electron cloud of the electron of the excited hydrogen atom in two different cases:



What is the principal quantum number (n) which is not probable for the electron in both cases ?

- (a) j
- **(b) 2**

- © 3
- (d) 4

Idea of answering:

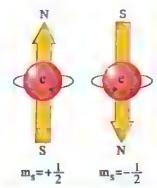
- : The figures illustrate the probable electron cloud of the electron of an excited hydrogon atom in two different cases.
- :. The electron has already transferred from the first principal energy level (n = 1) to a higher level.
- .. The principal quantum number of this electron is not probable to be (n = 1) in any of these cases.

Answer: The correct choice is (a)

The spin quantum number (m_c)

Any orbital cannot be occupied by more than two electrons, each electron spins around its own axis during its orbiting the nucleus.

- * The spin quantum number defines the type of spin motion of the electron around its axis in the orbital, which is either:
- Clockwise (\uparrow) with m_s value equals ($+\frac{1}{2}$).
- Anticlockwise ($\frac{1}{2}$) with m_s value equals ($-\frac{1}{2}$).
- * The spin motion of the electron around its own axis in a certain direction results in arising a magnetic field.



The spin motions of the two electrons of the same orbital

- * The opposite spin motion of the two electrons of
 the same orbital around their own axes results in arising two magnetic fields
 in two opposite directions (spin-paired state) (1/2).
- Orbitals have three different possibilities depending on the number of electrons located in them as follows:

	Empty orbital.
1	Half filled orbital contains a single (unpaired) electron.
1	Completely filled orbital contains 2 (paired) electrons that have opposite spinning directions (spin-paired state).

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?

G.R. Although the two electrons which are found in the same orbital carry the same negative charge, they don't repel each other.

Because the magnetic field which arises from the spinning of one electron is in a direction opposing the direction of the other magnetic field arising from the spinning of the other electron and that decreases the repulsive force between the two electrons.

Worked Example

Two electrons in the same atom lie in the second orbital of the same sublevel p in the same principal level $\mathbf M$

Write the four quantum numbers of the two electrons.

Idea of answering:

- .. The principal level is M
- .. The principal quantum number (n) of each of them is 3
- \therefore The sublevel is p
- \therefore The secondary (subsidiary) quantum number (ℓ) of each of them is 1
- : They both lie in the second orbital.
- .. The magnetic quantum number (m_l) of each of them is 0
- The two electrons in the same orbital are opposite in spin motion.
- \therefore The spin quantum number (m_s) of one of them is $(+\frac{1}{2})$ and that of the other is $(-\frac{1}{2})$.

Answer:

The four quantum numbers	n	l	mį	ms
First electron	3	1	0	$+\frac{1}{2}$
Second electron	3	1	0	$-\frac{1}{2}$

Summary of the quantum numbers-

Quantum	Used in the determination of	Application
Principal (n)	* The order of the principal energy levels. *Their number in the heaviest known atom is 7". K L M N O P Q * The number of the electrons required to saturate each principal energy levels (K to N) from the relation: 2n2	* The third principal energy level M becomes saturated with a number of electrons equals 2 × 3 ² = 18 e ⁻
Subsidiary (ℓ)	* Energy sublevels in each principal energy level. "Each principal energy level (n) contains a number of energy sublevels (l) that equals the numerical value of (n)". Sublevel Value of (l) Sublevel Value of (l) (l) values range between [0 : (n-1)]	* The third principal energy level M consists of: Three energy sublevels which are: S.p.d
Magnetic (m_l)	* Number of the orbitals in each principal energy level (n) from the relation: * Number of the orbitals in each energy sublevel (l) from the relation: 2l+1 * The spatial orientations of the orbitals. Each orbital is filled with 2 electrons (ml) values range between (-l, 0, +l)	* The third principal energy level M consists of number of orbitals equals (3 ² = 9 * Sublevel p whose value is 1 consists of a number of orbitals equals (2 × 1) + 1 = 3
Spin (m _s)	* The direction of motion of the electron around its axis (spin motion): • Either clockwise (†) its numerical value is (+½). • Or anticlockwise (↓) its numerical value is (-½).	* When the sublevel d contains 8 electrons, then the first electron in it will spin around its axis clockwise, and its (m _s) value will be (+ ½).

to saturate each principal level No. of the electrons required

 $(2n^{2})$

Summary of the relations between the principal level, the sublevels and the orbitals

Principal quantum number 3 Symbol of the principal level

The sublevels principal level in each

Secondary quentum number (b)

No. of the orbitals In each principal level (n²)

No. of the orbitals In each sublevel (2(+1)

2e⁻

11

X

2

8e-

П

4

X

2

4

0

S

×

0

25

сī

2p

m

0

30 38

3

Z

 $= 18e^{-}$

2 x 9

6

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S

2

34

45

0

4p

4

32e-

Ħ

16

×

N

91

3

S

2

44

m

45

Multiple choice questions

	Section of the Company of the Compan		ott cicia
11 The i	maximum possible value of th	e principal quantum number (n) in
the h	eaviest known atom in its gr	ound state is	
(a) 5	b 6	© 7	d 8
🛓 The i	naximum number of electron:	s which saturate the principal e	nergy level (n)
is giv	en from the relation		
a 2	(b) n ²	© 2n ²	(d) $(2n)^2$
🚺 Wha	t is the quantum number who	se value may never be zero or a	fraction?
a P	rincipal. (b) Subsidiary	y. © Magnetic.	d Spin.
1 The	orincipal quantum number (n)	of the electron of the sublevel	<i>3s</i> ¹ equals
a 0	(b) 1	© 2	d 3
The s	ymbols s, p, d, f indicate	41301	
a pr	rincipal energy levels.		
b е	nergy sublevels.		
© th	e number of orbitals of the sub	level.	
(d) th	e number of single electrons in	the individual sublevel.	
What	is the symbol of the principa	I level which contains s,p and a	sublevels only?
a L	(b) M	© N	@ K
Wher	(n = 2), then one of the poss	ible values of the subsidiary qu	antum number
is	0.200		
a -;	(b) 0	$\odot \frac{1}{2}$	d 2
8 What	is the quantum number whos	se value for an electron in the p	rincipal
energ	y level (L) is -1 ?		
(a) P ₁	incipal. (b) Subsidiary	(c) Magnetic.	(d) Spin.

The number of orbitals in each principal energy level (n) equals

(b) n −1

© 3n²

 $a n^2$

 \bigcirc $2n^2$

Ш	I the number of orbit	ais of the principal level	114 Equals	
	a 1	b 9	© 14	a 16
1	The orbitals in the s	ame sublevel are		
	a different in energ	ŗy.	(b) equal in energy.	
	© different in shape	e.	d different in size.	
0	What is the maximu	m number of electrons	required to saturate one o	orbital in
	4f sublevel ?			
	(a) 2e-	ⓑ 7е ⁻	© 10e-	d 14e-
Œ	What are the simila	r quantum numbers bet	ween the 2 electrons of th	e two orbitals
	$2p_{x}^{l}, 2p_{y}^{l}$?			
	(a) n , m_s , ℓ	\textcircled{b} n, ℓ , m_{ℓ} , m_{s}	© n, m _s	(d) n, m_l ,
1	Which of the follow	ing quantum numbers i	ts (their) values are never	negative ?
	a n only.	(b) ℓ only.	\bigcirc \mathbf{m}_l , \mathbf{m}_{s}	(d)n, l
Œ	The least possible v	value for the subsidiary	quantum number of the el	ectron whose
		number $(m_j = -1)$ is		
	a 0	b 1	© 2	@3
1	The highest value f	or the quantum number	m, of an electron found in	n the third
	principal energy lev		•	
	a 0	(b) +1	© +2	d +3
6	What are the three	guantum numbers whic	h are included in the solu	tion of the wave
			ctron in hydrogen atom ?	
	ⓐ n , ℓ , m _s		\textcircled{b} \mathbf{m}_{ℓ} , $\mathbf{m}_{\mathbf{s}}$, $\mathbf{m}_{\mathbf{p}}$	
	$\odot n, l, m_l$		$\oplus l, m_l, m_s$	
G	When the electron i	in hydrogen atom transf	iers from 4d to 2s, the em	itted photon is
	in the form of	-		The second second
	(a) infrared ray.	(b) ultraviolet ray.	© visible light.	d X ray.
0	All the following de	escribe the sublevel s , ϵ	except that	
	(a) it is found in all	principal energy levels o	f the atom.	
	b its size increases	by increasing the value	of n	
	its electron capa	city increases by increasi	ing the value of n	
	d its shape does no	ot change by changing th	e value of n	
لسم				

10 What is the su	blevel in which the last	t electron has the two quantum n	umbers
$(n=2, \ell=0)$?		
a 2s	(b) 2p	© 1s	(d) 3p
Which of the f	ollowing can be conclu	ded from the relation : $2\ell + 1 = 5$?
(a) This sublev	el is saturated with 10e-		
(b) This sublev	el is found in the second	d principal energy level.	
© The maximu	ım value of the magnetic	quantum number of the electrons of t	his sublevel is -3
d The maxim	um number of electrons	which saturate this sublevel is 5e-	
1 The electron w	hich has the two guan	tum numbers (n = 3, m_l = +2) mu	st have
the value			
		© l = 0	$\bigcirc l = 2$
Which of the fo	ollowing represents an	electron in an atom ?	
It is found in	***************************************		
		s subsidiary quantum number is 2	
		s magnetic quantum number is +1	
		ts subsidiary quantum number is 2	
(d) the sublevel	l d, and its principal qua	ntum number is 2	
Which of the formula	ollowing quantum num	bers represent an electron in the	orbital $3p_x$?
(a) $n = 3$, $l = 2$	$m_{\ell} = -1$	(b) $n = 3$, $l = 0$, $m_l = 0$	
© $n = 3$, $l = 0$	$, m_{\ell} = +1$	(d) $n = 3$, $l = 1$, $m_l = -1$	
T. Control of the Con		of quantum numbers represents a	an electron in
	tals of 5f sublevel?		
	$m_{\ell} = +4$, $m_{s} = +\frac{1}{2}$		
(b) $n = 5$, $l = 2$	$m_{\ell} = -2$, $m_{s} = +\frac{1}{2}$		
	, $m_{\ell} = +1$, $m_{s} = +\frac{1}{2}$		
(d) $n = 5$, $l = 4$	$m_{\ell} = -4$, $m_{g} = -\frac{1}{2}$		
		e sublevel $3d^5$ are similar in all th	e following,
except the	88 Deg 44 4 t		
	antum number.	(b) subsidiary quantum n	umber.
© magnetic qu	antum number.	d spin quantum number	•
			62

- The energy of the orbital $(3p_Z)$ is similar to that of the orbital
 - (a) 4p_y
- **b** 3р_у

© 3s

@ 1/2

- The two orbitals $(2s, 2p_x)$ can be similar in
 - (a) the energy.

- b the shape.
- (c) the number of electrons in each of them.
- d the spatial orientation.
- - (a) it becomes filled by 2 electrons.
 - (b) it belongs to the sublevel p
 - © it is one of the orbitals found in the first principal level.
 - (d) it is one of the orbitals found in the second principal level.
- The electrons of 5d sublevel in one of the atoms cannot have the magnetic quantum number
 - (a) +1
- (b) -1

© +2

- (d) +3
- The electron which has the magnetic quantum number (-3) may have the principal quantum number
 - a 1

b 2

© 3

- **d** 4
- Number of orbitals of the sublevel which has the values (n = 3), (l = 2) is
 - **a** 2
- **b** 3

(c) 5

d 7

- The electron which has the four quantum numbers :
 - $(n = 4, l = 3, m_l = +2, m_s = +\frac{1}{2})$ is found in the sublevel
 - (a) 3d
- (b) 4f

© 5p

- d) 6s
- Which of the following quantum numbers do not include a mistake?
 - (a) n = 5, l = 2, $m_l = -1$

(b) n = 3, l = 0, $m_l = +\frac{1}{2}$

© n = 4, l = 1, $m_l = -2$

- (d) n = 1, l = 1, $m_l = 0$
- Which of the following quantum numbers include a mistake?
 - (a) n=4 , l=2 , $m_l=-1$

(b) n = 4, l = 1, $m_l = 0$

© n = 3 , l = 0 , $m_l = 1$

(d) n = 2, l = 0, $m_l = 0$

- 55 State each of the following:
 - (1) The possible (l) values of the electrons in the principal energy level (n = 4).
 - (2) The possible (m_l) values of the electrons in the sublevel (l=3).
- Show which is higher, with elucidating the reason, the maximum number of electrons in the principal level (n = 2) or the maximum number of electrons in the sublevel (4d).
- Estimate the number of the orbitals which can be occupied by electrons in the principal level (n = 2).
- Estimate the number of the orbitals which are present in the sublevel 4d
- Suggest the value of the subsidiary quantum number of the orbital of 4s sublevel.
- the energy sublevels of the principal energy level (n = 4).

Complete the blank cells with the suitable magnetic quantum numbers (m_l).

Sublevel f	
Sublevel d	
Sublevel P	
Sublevel s	

Suggest the reason of invalidity of each of the following sets of quantum numbers :

$$(1) n = 3$$
, $l = 3$, $m_l = +2$

(2)
$$n = 2$$
 , $l = 1$, $m_l = -2$

(3)
$$n = 1$$
 , $l = 0$, $m_l = +\frac{1}{2}$, $m_s = +\frac{1}{2}$

Complete the following table:

(n)	(t)	(m _ℓ)	The orbital
2	1	-1	$2p_{_X}$
1	0	0	***************************************
4	******	+3	***************************************
*********		*******	4p _y
3	2	-2	***************************************

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The opposite figures represent 3 different orbitals in an atom, complete below figures (2) and (3) with what is suitable, taking into consideration the sizes of the orbitals.



Figure (1)

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Higher – order questions

Answered in detail

Choose the correct answer:

- What is the maximum number of electrons which can be found in the same atom and have the two quantum numbers $(n = 4, \ell = 1)$?
 - (a) 2e⁻
- (b) 6e⁻

(c) 8e⁻

- (d) 10e⁻
- Mhat is the maximum number of electrons which have the spin quantum number $(\mathbf{m}_s = +\frac{1}{2})$ in the sublevel $(\ell = 3)$?
 - (a) 3e
- (b) 5e⁻

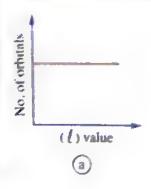
(c) 7e⁻

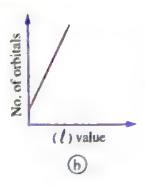
- (d) 14e⁻
- 57 Number of the electrons which saturate each sublevel is estimated from the relation
 - (a) 2(2l+1) (b) (2l+1)
- \bigcirc $2n^2$

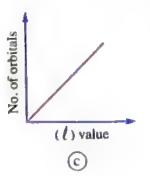
- \bigcirc n^2
- $oxed{48}$ If the number of the orbitals in a certain sublevel is $oldsymbol{x}$, then its subsidiary quantum number equals
 - $a \frac{x}{2}$
- (b) 2x 1

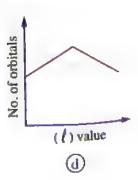
 $\bigcirc x-1$

- 49 Which of the following charts represents the relation between (ℓ) value and the number of the orbitals in the sublevel?

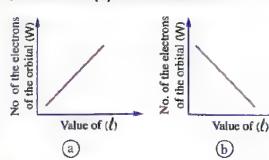


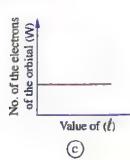


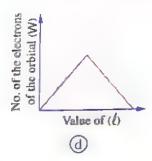




Which of the following graphical figures represents the relation between the number of the electrons which fill the orbital (W) in a certain sublevel and the value of (ℓ) of this sublevel?



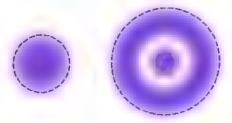




1 The two opposite figures represent two different sublevels.

What is the difference between them?

- (a) Subsidiary quantum number.
- (b) Distribution of electron density.
- (c) Principal quantum number.
- d Number of orbitals.



- 52 Which of the following becomes saturated with the highest number of electrons?
 - a) One of 4f orbitals.

- (b) 3d sublevel.
- \bigcirc Principal level (n = 2).
- (d) One of 3d orbitals.
- Solution (X) has the following quantum numbers: $(n = 3, \ell = 2, m_{\ell} = -1, m_{s} = -\frac{1}{2})$. What are the quantum numbers of the electron (Y) which have the same energy of the electron (X), but it differs from the electron (X) in the direction of the spin motion?

(a)
$$n = 3$$
, $l = 2$, $m_l = -1$, $m_s = +\frac{1}{2}$

(a)
$$n = 3$$
, $l = 2$, $m_l = -1$, $m_s = +\frac{1}{2}$ (b) $n = 3$, $l = 1$, $m_l = -1$, $m_s = -\frac{1}{2}$

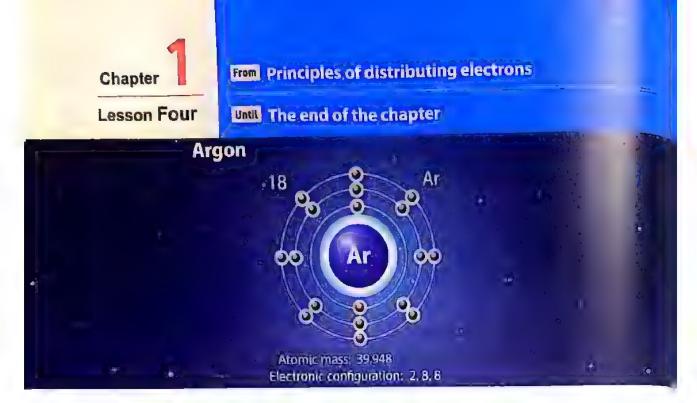
©
$$n = 3$$
, $l = 2$, $m_l = 0$, $m_s = -\frac{1}{2}$

Essay question:

Calculate the maximum number of electrons that can be found in an atom and have the following quantum numbers:

$$(1) n = 3$$

(2)
$$n = 2$$
, $l = 0$



Principles of distributing electrons

There are some important rules, which must be considered in distributing electrons in the atom. These rules are:

- Pauli's exclusion principle.
- 2 Aufbau (building-up) principle.
- 3 Hund's rule.

There is another method for distributing electrons in the element according to the nearest noble gas that precedes it in the periodic table, this will be discussed in chapter 2



Pauli's exclusion principle

Pauli's exclusion principle:

States that it is impossible for two electrons in the same atom to have the same four quantum numbers.



Application

The opposite table shows the two electrons of the (3s) sublevel which are similar in the values of the quantum numbers (n, ℓ, m_ℓ) , but they are different in the two values of the spin quantum number (m_e) .

The four quantum no.	n	E	\mathbf{m}_l	m _s
The first electron	3	0	0	+ 1/2
The second electron	3	0	0	$-\frac{1}{2}$

Worked Example

Write the possible values of the four quantum numbers for each of the following:

- (a) An electron in 2p
- (b) The first electron in 4d
- (c) The second electron in Is

Answer :-

The quantum numbers		n	l	$m_{\ell} = -\ell,, 0,, +\ell$	$m_{s} = \pm \frac{1}{2}$
	(a)	2	1	-1 or 0 or +1	$+\frac{1}{2}$ or $-\frac{1}{2}$
The possible values of quantum numbers	(b)	4	2	-2	+ 1/2
	(c)	1	0	0	$-\frac{1}{2}$

Test Yourself

In helium atom 2He,

- (a) the values of the spin quantum number are similar.
- (b) $m_{1} = 1$
- (c) the values of the spin quantum number are different.
- (d) $m_1 = -1$

Answer: The correct choice is

Aufbau (building-up) principle

Aufbau (building-up) principle:

States that the electrons occupy the sublevels in the order of increasing their energy, the lowest energy sublevels are filled first.

- * Arrangement of sublevels according to their energy depends on :
 - Sum of (n + l).
 - Ex. Energy of 4s sublevel is lower than that of 3d sublevel... G.R.?

Because the sum of $(n + \ell)$ of 4s sublevel is less than that of 3d sublevel.

Order of the principal energy level.

"In case that the sum of $(n + \ell)$ value is the same for the two sublevels".

5	Sequence of filling energy sublevels	7
Į	Sed	,

Sublevels	Sum of $(n + \ell)$	
3p	3+1=4	
4s	4+0=4	
3d	3+2=5	

69

Ex. Energy of 3p sublevel is lower than

that of 4s sublevel ... G.R.?

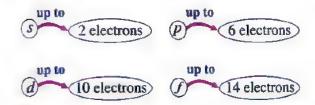
Because (n) value of 3p sublevel is lower than that of 4s sublevel.

* The sequence of energy sublevels is arranged ascendingly according to their energy following the order:

$$1s < 2s < 2p < 3s < 3p < 4s < 3d < 4p < 5s < 4d$$

 $< 5p < 6s < 4f < 5d < 6p < 7s < 5f < 6d < 7p$

* Filling the energy sublevels:





A simplified method of filling energy sublevels by following the direction of the arrows

"Numbers 1: 8 represent the sum of (n + \(l\))
of each sublevel"

Test-Yourself

What is the number of the orbitals whose (n + l) is less than 5?

(a) 4

(b) 8

© 9

(d) 10

Answer: The correct choice is

Worked Example

is correct?

The opposite table shows the quantum numbers of three electrons (X), (Y) and (Z) in the same atom.

Which of the following statements

Quantum numbers	(n)	(b)	(\mathbf{m}_{ℓ})	(m_s)
Electron (X)	4	3	0	$+\frac{1}{2}$
Electron (Y)	6	0	0	+ 1/2
Electron (Z)	5	2	-1	$-\frac{1}{2}$

- (a) The energy of electron (Y) is higher than that of electron (X).
- (b) The energy of electron (X) equals that of electron (Z).
- © The energy of electron (Z) is higher than that of electron (Y).
- d The energy of electron (Y) is higher than that of electron (Z).

Idea of answering:

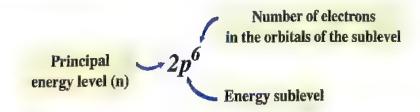
* The energy of the electron increases with increasing the value of $(n + \ell)$ and vice versa.

Electron	(X)	(Y)	(Z)
$(n + \ell)$ value	4+3=7	6+0=6	5+2=7

- The energy of electron (Y) is lower than those of both (X) and (Z).
- :. The choices (a) and (d) are excluded.
- : The (n) value of electron (Z) is higher than that of electron (X).
- :. The energy of electron (Z) is higher than that of electron (X).
- :. The choice (b) is excluded.

Answer: The correct choice is ©

* The electronic configuration of an energy sublevel can be expressed as follows:



Worked Example

Write the electronic configuration for the following elements, according to the building-up principle:

Answer:

(1)
$$_{11}$$
Na: Is^2 , $2s^2$, $2p^6$, $3s^1$

(2)
$$_{20}$$
Ca: $1s^2$, $2s^2$, $2p^6$, $3s^2$, $3p^6$, $4s^2$

(3)
$$_{32}$$
Ge: $1s^2$, $2s^2$, $2p^6$, $3s^2$, $3p^6$, $4s^2$, $3d^{10}$, $4p^2$

Notes

* The elements whose valence electrons are present in sublevels (n)s, (n-1)d like:

$$_{21}$$
Sc: $1s^2$, $2s^2$, $2p^6$, $3s^2$, $3p^6$, $4s^2$, $3d^1$

tend during the chemical reactions to lose the electrons of the lower energy (n)s sublevel (which is farther from the nucleus) first, then those of the higher energy (n-1)d sublevel (which is closer to the nucleus).

st It is clear in the electronic configuration of manganese element $_{25}\!Mn$ that :

$$_{25}$$
Mn: $1s^2$, $2s^2$, $2p^6$, $3s^2$, $3p^6$, $4s^2$, $3d^5$

- The farthest electron from the nucleus occupies the sublevel 4s
- The last electron in the atom occupies the sublevel 3d

Worked Example

The electronic configuration of zinc atom $_{30}{
m Zn}$ is represented as follows :

$$_{30}$$
Zn: Is^2 , $2s^2$, $2p^6$, $3s^2$, $3p^6$, $4s^2$, $3d^{10}$

Conclude the quantum numbers of :

- (1) The last electron with the highest energy in the atom of this element.
- (2) The farthest electron from the nucleus of the atom of this element.

Answer:

(1)
$$n = 3$$
, $l = 2$, $m_l = +2$, $m_s = -\frac{1}{2}$ $3d^{10}$

(2)
$$n = 4$$
, $l = 0$, $m_l = 0$, $m_s = -\frac{1}{2}$ $4s^2$

3 Hund's rule

Hund's rule:

States that no electron pairing takes place in a given sublevel until each orbital contains one electron.



• Rules of filling the energy sublevels with electrons, according to Hund's rule :

Rules	Applications
The orbitals of the same sublevel are equal in their energy	The three 2p orbitals are equal in energy are equal in energy
The orbitals of the same sublevel are filled successively by the unpaired electrons firstly, the spinning of single electrons is in the same direction	p_{x} p_{x} p_{y} p_{x} p_{y} p_{z} p^{1} p^{2} p^{2} p^{3} p^{3} p^{2} The successive filling of p orbitals with unpaired electrons first
Electron pairing takes place in the orbitals of the same sublevel after occupying all orbitals by the unpaired electrons first, and these paired electrons have opposite spin directions (being in a spin-paired state) "According to Pauli's exclusion principle"	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$
The electron prefers to be paired with another electron in one orbital of the same sublevel rather than being transferred to a higher energy sublevel	2pl

G.R. (1) The spinning of the single (unpaired) electrons in the orbitals of the sublevel is in the same direction.

Because this state gives the atom maximum stability.





(2) The electron prefers to occupy a separate empty orbital in the same sublevel rather than pairing with another one in the same orbital.

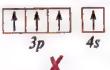
Because when two electrons are paired in one orbital, (despite their opposite spinning), there must be a repulsive force that decreases the stability of the atom (increasing its energy).





(3) The electron prefers pairing with another one in an orbital in the same sublevel rather than travelling to the higher energy sublevel.

Because the required energy to overcome the repulsive force between the two paired electrons is less than that required for travelling to a higher energy sublevel.

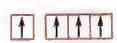




Notes

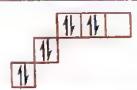


The electronic distribution obeys Aufbau principle, but violates Pauli's exclusion principle



The electronic distribution obeys Pauli's exclusion principle, but violates

Aufbau principle



The electronic distribution obeys both Aufbau principle, and Pauli's exclusion principle, but violates Hund's rule

Application \

The electronic configuration of some elements according to building-up principle and Hund's rule :

Element	Atomic number	Electronic configuration according to building-up principle	Electronic configuration according to Hund's rule
Hydrogen 1H	1	1s ¹	1s ¹
Helium 2He	2	Is ²	1s ² 1
Lithium ₃ Li	3	Is^2 , $2s^I$	$2s' \uparrow$ $1s^2 \downarrow \downarrow$
Boron ₅ B	5	$1s^2$, $2s^2$, $2p^1$	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$
Carbon 6C	6	$1s^2$, $2s^2$, $2p^2$	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$
Nitrogen 7N	7	$1s^2$, $2s^2$, $2p^3$	$ \begin{array}{c c} 2p^{3} & \uparrow & \uparrow \\ 2s^{2} & \downarrow \\ Is^{2} & \downarrow \\ Is^{2} & \downarrow \\ Is^{2} & , 2s^{2} & , 2p_{X}^{I} & , 2p_{Y}^{I} & , 2p_{Z}^{I} \end{array} $
Fluorine 9F	9	Is^2 , $2s^2$, $2p^5$	$2p^{5} \downarrow \downarrow \downarrow \downarrow$ $2s^{2} \downarrow \downarrow$ $1s^{2} \downarrow \downarrow$ $1s^{2}, 2s^{2}, 2p_{x}^{2}, 2p_{y}^{2}, 2p_{z}^{I}$
Neon 10Ne	10	$1s^2, 2s^2, 2p^6$	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$

pplication

Quantum numbers of electrons of carbon atom 6C:

$$_{6}$$
C: $1s^{2}$, $2s^{2}$, $2p^{2}$

Electron	1	2	3	4	5	6
, n	1	1	2	2	2	2
1	0	0	0	0	1	1
m _l	0	0	0	0	-1	0
m _s	+1/2	$-\frac{1}{2}$	+ 1/2	$-\frac{1}{2}$	+ 1/2	+1/2

Worked Examples

f j Predict the possible quantum numbers of the valence electrons of vanadium element ${}_{23} m V$

Answer:

- Electronic configuration of the atom of $_{23}$ V is: $1s^2$, $2s^2$, $2p^6$, $3s^2$, $3p^6$, $4s^2$, $3d^3$
- The possible quantum numbers are :

①
$$n = 4$$
, $l = 0$, $m_l = 0$, $m_s = +\frac{1}{2}$ ② $n = 4$, $l = 0$, $m_l = 0$, $m_s = -\frac{1}{2}$

②
$$n = 4$$
, $l = 0$, $m_l = 0$, $m_s = -\frac{1}{2}$

3
$$n = 3$$
, $l = 2$, $m_l = -2$, $m_s = +\frac{1}{2}$ 4 $n = 3$, $l = 2$, $m_l = -1$, $m_s = +\frac{1}{2}$

(4)
$$n = 3$$
, $l = 2$, $m_l = -1$, $m_s = +\frac{1}{2}$

$$5_{n} = 3, l = 2, m_{l} = 0, m_{s} = \pm \frac{1}{2}$$

Three elements (X), (Y) and (Z):

- Element (X): Its principal energy level (n = 3) contains 3 electrons.
- Element (Y): Its last sublevel is 3s which is half filled with electrons.
- Element (Z): Its electronic configuration is $1s^2$, $2s^2$, $2p^3$

Which of the following are the atomic numbers of (X), (Y) and (Z)?

Choices	(X)	(Y)	(Z)
a	11	7	13
b	11	13	7
©	13	11	7
(d)	13	7	11

idea of answering:

- : The electronic configuration of element (X) is : $1s^2$, $2s^2$, $2p^6$, $3s^2$, $3p^1$
- : The atomic number of element (X) = 13
- .. The choices (a) and (b) are excluded.
- : The electronic configuration of element (Y) is : $1s^2$, $2s^2$, $2p^6$, $3s^1$
- ... The atomic number of element (Y) = 11
- .. The choice d is excluded.
- : The electronic configuration of element (Z) is: $1s^2$, $2s^2$, $2p^3$
- \therefore The atomic number of element (Z) = 7

Answer: The correct choice is ©

- An element (X) whose electrons are distributed in four principal energy levels, and its last energy level contains 6 electrons:
 - (1) Write the full electronic configuration of the ion (X^{2-}) .
 - (2) What is the number of the unpaired electrons in the last sublevel in the atom of this element?
 - (3) What are the quantum numbers of the last electron in the atom of this element?

Answer:

(1) : The full electronic configuration of the element atom (X):

$$1s^2$$
, $2s^2$, $2p^6$, $3s^2$, $3p^6$, $4s^2$, $3d^{10}$, $4p^4$

 \therefore The full electronic configuration of the ion (X²⁻):

$$1s^2$$
, $2s^2$, $2p^6$, $3s^2$, $3p^6$, $4s^2$, $3d^{10}$, $4p^6$

(2) 2 unpaired electrons.

(3)
$$4p^4$$
 1, \uparrow \uparrow $n=4$, $\ell=1$, $m_\ell=-1$, $m_s=-\frac{1}{2}$

Questions 🛜

Chapter

Lesson Four

Multiple choice questions





Pauli's exclusion principle

1	The two electrons of 3s sublevel differ in th	e
	a principal quantum number.	(b) subsidiary quantum number.
	© magnetic quantum number.	d spin quantum number.
6	Which of the following statements is correct	t?
	(a) It is possible sometimes to determine the	position and the speed of the electron
	together precisely at the same time.	
	b The sizes of the orbitals of the same atom	are similar.
	© The probability of the presence of the elec-	ctron in the spaces between the energy levels
	increases.	
	d The two electrons of helium do not have	the same four quantum numbers.
£	If two electrons have the same four quanto	ım numbers, it means that these two
	electrons are found in	
	a) the same principal level.	b) two different atoms.
	© the same orbital.	d the same sublevel.
•	The two electrons in the same atom which	have the same l , \mathbf{m}_{s} values are located
	in the same	
	a sublevel but in two different orbitals.	
	(b) principal level but in two different suble	vels.
	© orbital.	
	d principal level but in two different orbita	ls.
1	The values of the spin quantum number of	f the electrons of the orbitals of the same
	sublevel differ when the number of its ele	ctrons
	(a) equals half the number of the orbitals.	(b) is higher than the number of the orbitals
	is lower than the number of the orbitals.	d equals the number of the orbitals.
_		

A	Aufbau (Building	up) principle		
6 (n	+ () represents t	he energy of the	****	
(a) sublevel.	(b) atom.	© principal level.	d electron cloud.
Ø W	hen the <i>3d</i> subles	el is completely fille	d with electrons, the new e	lectron occupies
th	ıe			
(2)	4s sublevel.	\bigcirc 4p sublevel.	© 4d sublevel.	d $4f$ sublevel.
8 If	the energy sublev	d in an atom contains	ins $8e^-$, so the number of it	s half filled orbitals
is	************			_
(3	1	(b) 2	© 4	(d) 5
9 W	hat is the number	of the completely filled	orbitals in a carbon atom ${}_6{\rm C}$	in its ground state?
(3	1	b 2	© 3	d 5
TI 📆	he total number o	f the half filled orbita	ls in ${}_9{f F}$ atom in its ground	state is
(a) 1	b 2	©3	(d) 5
W	hich of the follow	ing sublevels has the	least energy ?	
Ta	ns	\bigcirc $(n-1)p$	\bigcirc $(n-2)d$	\bigcirc $(n-3)p$
<u> </u>	ccording to the bu	uilding-up principle,	him x ≈ 6 d/6 6 € 4 d/6 4	
(a) it is impossible t	o determine both the p	osition and the speed of the	nuclear particles
	together precisel			
		pies the orbital with the	ne lower energy first.	
		ins mostly 2 electrons.	whitele simple first before be	
a	the electrons occ	upy the equal energy of	orbitals singly first before be	ing paired.
13 W	hich is easier, losi	ng an electron from 3	d or from 4s?	
		closer to the nucleus th		
_		closer to the nucleus th		
9		farther from the nucleu		
		farther from the nuclei		
			ch have magnetic quantum	number $(m_{\ell} = 0)$
	cobalt (II) ion 27		€ 10-7	(i) 11-7
Ι.) 7e ⁻	(b) 8e ⁻	© 10e ⁻	(d) 11e ⁻
			re filled with electrons in ti	ne two energy
1		ie atom of argon ₁₈ Ar	_	(D.12)
a) 4	(b) 8	© 9	@ 13

- 16 Which of the following represents the possible quantum numbers of the last electron in oxygen atom?
 - (a) n=2 , l=1 , $m_1=+1$, $m_2=+\frac{1}{2}$
- Which of the following are the possible quantum numbers of the last electron which has the highest energy in vanadium 23V atom?
 - (a) n = 3 , l = 2 , $m_l = 0$, $m_s = +\frac{1}{2}$
- 18 Which of the following are the quantum numbers of the 19th electron in the atom of chromium 24Cr?
 - (a) n=3 , l=0 , $m_s=+\frac{1}{2}$
- 19 Which of the following combinations of quantum numbers represents the single electron in the atom of gallium element 31Ga?

Choices	n	l	(m _l)	(m _s)
a	3	1	+1	$+\frac{1}{2}$
Ь	4	0	0	$-\frac{1}{2}$
©	4	1	-1	$+\frac{1}{2}$
(1)	4	2	+1	+ 1/2

- Which of the electrons that have the following quantum numbers has the highest energy?
 - (a) n = 3 , l = 2 , $m_l = +1$, $m_s = +\frac{1}{2}$

	number of the electro			and all and and				
(n=4) in the	ne atom of potassium e	_						
(3) 1e ⁻	ⓑ 2e [−]	© 36			d 4	le ⁻		
What is the	number of the electro	ns which hav	e the sam	$\mathbf{e}^{oldsymbol{\ell}}$ and $\mathbf{m}_{oldsymbol{\ell}}^{oldsymbol{v}}$ v	alue	s in 1	the a	ton
of the elem	ent ₁₅ X ?							
(a) 3e ⁻	b 5е ⁻	© 96			(1)	5e ⁻		
The opposit	te table represents the		Enero	y level	K	L	M	N
	electrons which are pre			of electrons	2	8	8	2
	al energy levels of an a	tom of	(Aminoci)	Ji Ciccions				
	in its ground state.					. L	11 .	41.7
_	number of the electron	_		ary quantum			(t = .	1) :
(a) 8e ⁻	ⓑ 10e ⁻	© 12	e		d) 2	ve		
What is the	atomic number of the	element who	se electro	ns occupy 8	orbi	tals	?	
a 8	b 14	© 15	;		(1) 2	16		
	atomic number of this	element?		illed orbital				
Choices	atomic number of this Number of the comp	element ?			nic n	umb		
	atomic number of this	element ?			nic n 25	umb		
Choices	atomic number of this Number of the comp	element ?			nic n	umb		
Choices	Number of the comp	element ?			nic n 25	umb		
Choices a b	Number of the comp	element ?			25 20	umb		
Choices a b c d The number value of the the atom of	Number of the comp Number of the comp 10 12 13 15 16 17 17 17 18 18 19 19 10 10 10 10 10 10 10 10	element ? letely filled of	with electrons of	Aton trons equals of the last en	nic n 25 20 22 24 s the nergy	nun / sub	er	al
Choices a b c d The number value of the	Number of the comp 10 12 13 15 16 17 17 17 18 18 19 19 10 10 10 10 10 10 10 10	element ? letely filled o	with electrons of	Aton trons equals of the last en	25 20 22 24	nun / sub	er	al
Choices a b c The number value of the atom of a 7N What is the	Number of the comp Number of the comp 10 12 13 15 16 17 17 17 18 18 19 19 10 10 10 10 10 10 10 10	element? letely filled of the element? are half filled mber of the element?	with electrons of	Aton trons equals	25 20 22 24 s the nergy	num / sub	er	al
Choices a b c d The number value of the atom of a 7N What is the number -3	Number of the comp 10 11 12 13 15 16 17 17 18 18 19 19 10 10 10 10 10 10 10 10	element? letely filled of the element? are half filled mber of the element.	with electrons of	Aton trons equals	nic n 25 20 22 24 s the nergy	num / sub	er	al
Choices a b c The number value of the the atom of a 7N What is the	Number of the comp Number of the comp 10 12 13 15 16 17 17 17 18 18 19 19 10 10 10 10 10 10 10 10	element? letely filled of the element? are half filled mber of the element?	with electrons of	Aton trons equals	25 20 22 24 s the nergy	num / sub	er	al

- An element its valence shell contains a number of electrons equals each of :
 - Number of the principal levels.
 - Number of the sublevels.
 - Number of its orbitals.

What is the symbol of this element?

- a _zLi
- (b) ₂He
- © Be

- \mathbb{Q}^{r}
- 29 In iron element $_{26}$ Fe, the number of the half filled orbitals is equal to the value of one of the quantum numbers of the farthest electron from the nucleus.
 - Which of the following is this quantum number?
 - (a) Principal quantum number.
- (b) Subsidiary quantum number.
- (c) Magnetic quantum number.
- (d) Spin quantum number.
- 30 What is the number of electrons of the penultimate principal energy level of the element whose atomic number is 28?
- (b) 8e⁻
- (c) 14e⁻

- (d) 16e⁻
- 31 What is the electronic configuration of the outermost (third) energy level of a stable atom that has 7 valence electrons?
 - (a) 351, 306
- (b) $3s^1$, $3p^4$, $3d^2$ (c) $3s^2$, $3p^5$
- (d) $3s^2$, $2p^4$, $3d^1$
- What is the electronic configuration which represents an excited atom?
 - (a) 182, 251

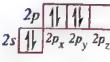
(b) $1s^2$, $2s^2$, $2p^6$, $3s^2$

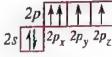
(c) $1s^2$, $2s^2$, $2p^2$, $3s^1$

(d) $1s^2$, $2s^2$, $2p^3$

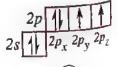
Hund's rule

- According to Hund's rule, the electron configuration of nitrogen element (7N) is
 - (a) $1s^2$, $2s^2$, $2p^3$
- (b) 2, 5
- © $1s^2$, $2s^2$, $2p_x^I$, $2p_y^I$, $2p_z^I$ d $1s^2$, $2s^I$, $2p^4$









(b)

3	The presence of 3 unpaired electrons in	phosphorus atom ₁₅ P in its	ground state can
	be explained by		
	(a) Pauli's exclusion principle.	(b) Hund's rule.	
	c the uncertainty principle.	d Aufbau principle.	
	ustitus at the following violetes Devil's my	insinlo 2	
36	Which of the following violates Pauli's p		
		(1)	
37	This configuration of fluorine atom ₉ F in		*
	its stable state does not obey		1
	(a) Aufbau principle only.		11
	(b) Hund's rule only.		
	© exclusion principle only.		
	d both Hund's rule and exclusion princip	le.	
	Essay que	stions	_
38	Reuse the opposite figure of the three axe	S	y
	to draw the shapes of the sublevels in		تر ا
	the principal level $(n = 2)$.		
39	According to Pauli's exclusion principle, no		
	in the same atom can have the same four qu		
	What are the similarities between the pos		
	electrons found in the orbitals of 2p sublev	el? In what may they diffe	er?
40	Apply Pauli's principle to the two electrons	of the last orbital of chloric	de ion ₁₇ Cl ⁻
41	Illustrate with explanation whether each	of Pauli's principle and Hu	nd's rule is
	applied to each of the following cases:		
		(2)	
42	Deduce the atomic number of the element	whose last electron has the c	juantum numbers :
	$(n=2, \ell=1, m)$	$m_{c} = +1$, $m_{c} = +\frac{1}{2}$	

What is the maximum number of electrons in an atom in which the last electron with the highest energy has the two quantum numbers:

(1)
$$n = 3$$
, $m_s = +\frac{1}{2}$

(2)
$$n = 4$$
, $m_1 = +3$

- An element (X) its electrons are distributed in four principal energy levels, the last level contains a number of electrons equals double the number of electrons of the energy level K:
 - (1) Write the full electronic configuration of the element (X) according to Aufbau principle.
 - (2) What are the quantum numbers of the electron in the last energy sublevel in the atom of this element?

Higher order questions Answered in detail

Choose the correct answer:

- The two electrons, found in the same sublevel, which have the same \mathbf{m}_s value must differ in the value(s) of
 - ② n only.

(b) ℓ only.

© m_l only.

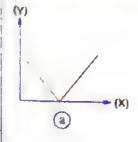
- d l and m,
- What is the number of electrons of the last principal energy level in the element which contains 15 completely filled and 2 half filled orbitals?
 - (a) 2e⁻

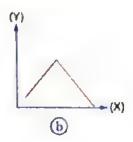
b 3е⁻

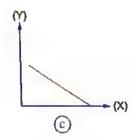
© 4e⁻

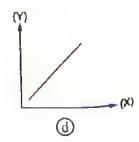
(d) 5e⁻

Which of the following charts represents the relation between (X) which represents the number of the electrons of the sublevel 3d and (Y) which represents the number of the single (unpaired) electrons in this sublevel ?









		nt consists of 3 orbitals · ℓ) of this sublevel equa	
What is the ato	mic number of this el	ement?	
(a) 19	(b) 31	© 33	d 41
49 An element (X)	, the principal quantu	m number of its farthes	t electron from
the nucleus is (n = 4), if the number of	of electrons found in the	energy level M is double
their number in	the level L		
What is the ato	mic number of (X)?		
a 18	(b) 26	© 28	d 36
The atom of ele	ment (X) has 3 occup	ied principal levels, and	the summation of
the spin quantu	m numbers of its vale	ence electrons is $1\frac{1}{2}$	
(assuming the p	ossibility of summati	on).	
What is the ato	mic number of eleme	nt (X) ?	
a 14	b 15	© 18	d 23
The last subleve	el in X^{3+} ion is $2p^6$		
What is the nur	nber of the half filled	orbitals in the atom of	(X) ?
a Zero	b 1	©2	d 3
Which of the fol	lowing represents the	e electronic configuration	on of the atom of
gallium 31Ga in	its excited state?		
a 2, 8, 17, 3	(b) 2, 8, 17, 4	© 2, 8, 18, 3	(d) 2, 8, 18, 4
Which of the fol	lowing represents the	e spin motion of the elec	ctrons of the last
energy sublevel	in ₁₈ Ar atom ?		
a 1 1 1		6111	
© 11 11 11		01111	
According to Hu	nd's rule and Pauli's	exclusion principle, the l	ast two electrons
		nent ₂₆ X are different in	the two quantum
numbers	0005		
a l and m	\bigcirc n and m_l	$\bigcirc l$ and m_s	\bigcirc m _l and m _s
			85

Exam model



on Chapter 1

Choose the correct answer for the questions 1: 20





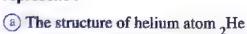
- A student has presumed wrongly that the two electrons (X) and (Y) which are in the same atom have the following quantum numbers:
 - Electron (X): n = 4, l = 0, $m_s = +\frac{1}{2}$
 - Electron (Y): n = 4, $\ell = 0$, $m_{f} = 0$, $m_{g} = +\frac{1}{2}$

What is the rule or the principle which explains this mistake?

- (a) Pauli's exclusion principle.
- (b) Aufbau principle.

© Hund's rule.

- d Uncertainty principle.
- The number of the orbitals of the sublevel which has the two values (n = 4, ℓ = 3)
 - (a) 2
 - (b) 3
 - © 5
 - (d)7
- What does the opposite figure represent?



- **(b)** The two electrons of p_x are in a spin-paired state.
- © The two electrons of the same orbital carry the same charge.
- d) Hund's rule.
- What is the atomic number of the element whose level which has the principal quantum number (n = 3) contains 13 electrons?
 - (a) 17
 - (b) 23
 - © 25
 - (d) 43

5 The opposite figure demonstrates the energy levels of a hypothetical atom, if an electron transfers from the energy level M to K, then it



- (a) acquires an amount of energy equals $5 \times 10^{-19} \text{ J}$
- (b) acquires an amount of energy equals 12×10^{-19} J
- © loses an amount of energy equals 5×10^{-19} J
- (d) loses an amount of energy equals 12×10^{-19} J
- 6 An electron with the quantum numbers :

$$(n = 4, l = 1, m_l = -1, m_s = +\frac{1}{2}).$$

What is the sublevel of this electron?

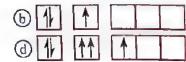
- (a) 4s
- (b) 4p
- (c) 4d
- (d) 4f
- What is the maximum number of electrons that can have the quantum numbers $(n=3, \ell=1, m_{\ell}=-1)$ in the same atom ?
 - (a) 10e⁻
 - (b) 6e⁻
 - © 4e⁻
 - d 2e-
- The electrons of the last energy level in neon $_{10}$ Ne atom occupy several orbitals which have two different shapes.

Which of the following represents correctly one of these orbitals?

Choices	Shape of the orbital	Energy of this orbital compared to the other orbitals
(a)	00	Higher than or equal to them
(b)	0	Higher than or equal to them
0	00	Lower than or equal to them
(1)		Lower than or equal to them

- 9) The number of the electrons found in the orbitals of s sublevel equals that found in the orbitals of p sublevel in the atom of
 - (a) 14Si
- (b) 12Mg
- © 11Na
- \bigcirc $_{7}N$
- $oxed{10}$ On comparing the energy and the charge of the electrons in the energy level ${f L}$ in beryllium Be atom to those of the electrons of the energy level K they are found to have
 - (a) lower energy but the same charge.
- (b) higher energy but the same charge.
- c) lower energy but the same (n) value.
- (d) higher energy but the same (n) value.
- 11) Which of the following electronic configurations violates Aufbau principle?

a	1	1	1		
0	†		1	+	1



12 Which of the following sets of quantum numbers expresses the electron of an excited hydrogen atom?

(a)
$$n=4$$
, $l=3$, $m_{\ell}=-3$
(b) $n=4$, $l=4$, $m_{\ell}=-2$
(c) $n=5$, $l=-1$, $m_{\ell}=+2$
(d) $n=3$, $l=1$, $m_{\ell}=-2$

(b)
$$n = 4$$
, $l = 4$, $m_l = -2$

©
$$n = 5$$
 , $l = -1$, $m_l = +2$

(d)
$$n = 3$$
 , $l = 1$, $m_{\ell} = -2$

- (13) What is the maximum number of electrons in an atom which has the two quantum numbers $(n=2, \ell=1)$?
 - (a) 2
- **(b)** 4

- (c) 6
- (d) 10
- 44 What is the correct order of the orbitals in titanium $_{22}$ Ti atom according to the increase of energy?
 - (a) 3s < 3p < 3d < 4s

(b) 3s < 3p < 4s < 3d

© 3s < 4s < 3p < 3d

- (d) 4s < 3s < 3p < 3d
- 15 Which of the following electronic configurations represents the ground state of an atom that contains 8 electrons?



6 1 1	1 1	
4 1	1	1

	6	What is the atomic number of the atom of the element whose orbitals contain
٦.		3 unpaired electrons ?

a 5

(b) 13

© 15

@ 21

Which of the following transfers in hydrogen atom produces the largest quantum of energy ?

(a) $(n = 7) \longrightarrow (n = 6)$

(b) $(n = 6) \longrightarrow (n = 5)$

(c) $(n = 4) \longrightarrow (n = 3)$

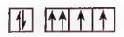
(d) $(n = 2) \longrightarrow (n = 1)$

Which of the following represents the electronic configuration of an excited phosphorus atom ?

- (a) $1s^2$, $2s^2$, $2p^6$, $3s^2$, $3p^3$
- b $1s^2$, $2s^2$, $2p^6$, $3s^2$, $3p_x^I$, $3p_y^I$, $3p_z^I$
- © $1s^2$, $2s^2$, $2p^6$, $3s^2$, $3p^2$, $4s^1$
- (d) $1s^2$, $2s^2$, $2p^6$, $3s^2$, 3p

Among the modifications introduced by the modern atomic theory to the older theories is

- a) it is impossible to determine both the position and speed of the 11th electron in 11^{Na} atom precisely at the same time.
- b the electron is negatively charged.
- © most of the atomic volume is an empty space.
- d the spaces between energy levels are forbidden for the electrons.
- The opposite electronic configuration violates



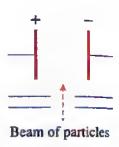
- (a) Aufbau principle only.
- b Pauli's exclusion principle only.
- © Hund's rule only.
- d Pauli's principle and Hund's rule.

Answer the essay questions 21: 23

The scientists discovered the presence of the electrons, protons and neutrons in the atom during the centuries 19 and 20,

if a beam of each of them is passed through an electric field (as in the opposite figure).

In which direction will the deflection be ? Explain.



2 marks

Compare between Thomson's atomic model and Rutherford's atomic model in 2 points only.

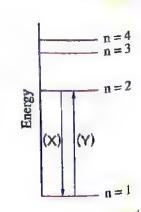
23 In the opposite figure :

Which of the two processes

(X) and (Y) requires losing energy?

What is the scientific term of this amount of one

What is the scientific term of this amount of energy in the light of Bohr's theory ?









The Periodic Table and Classification of Elements

Lesson One

From: The long form (modern) periodic table.

Until: Before trends and periodicity of properties in

the periodic table.



Lesson Two

From: Trends and periodicity of properties in the periodic table.

Until: Before metallic and nonmetallic property.

Lesson Three

From: Metallic and nonmetallic property.

Until: Before the oxidation numbers.

Lesson Four

From: The oxidation numbers.

Until: The end of the chapter.

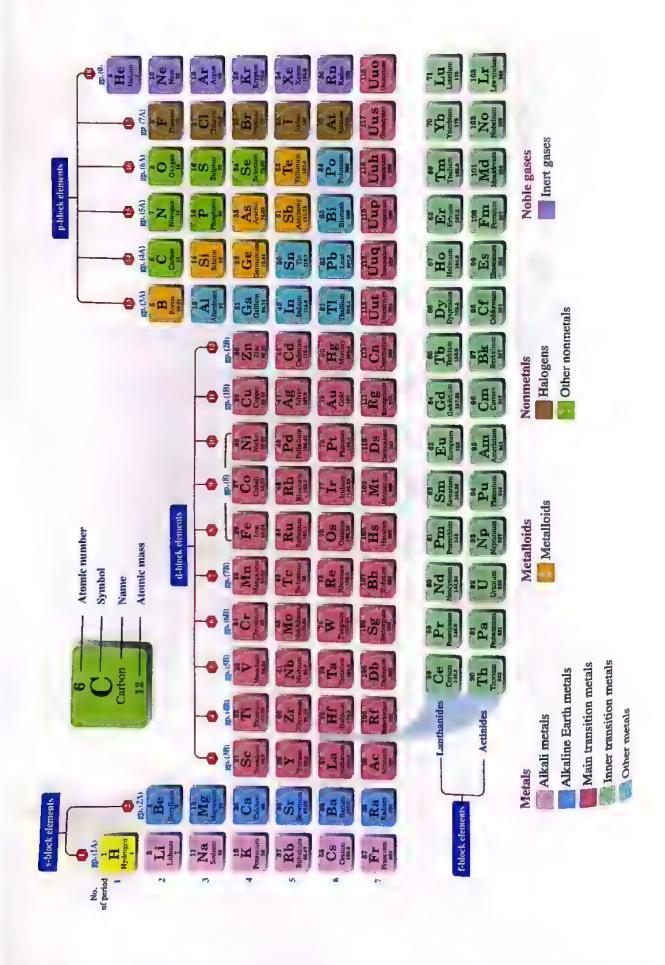


Exam model on the chapter

Learning outcomes

By the end of this chapter, the student will be able to :

- Describe the long form periodic table.
- Arrange the energy sublevels according to the building-up principle.
- Identify the type of the element and its properties from its location in the table.
- Calculate the atomic radius by using bond length.
- Explain the factors affecting the atomic radius across the periods and groups.
- Define the location of the four blocks of the table.
- Find the relationship between the electronic configuration of the elements of the same groups.
- Define the atomic radius, ionization energy, electron affinity and electronegativity.
- Compare between the electron affinity and electronegativity.
- Identify the location of metals and nonmetals.
- Find the relationship between atomic radius, ionization energy and electron affinity in metals and nonmetals.
- Identify the relationship between the atomic radius and the acidic and basic properties.
- Discuss the ionization of acids and bases as hydroxyl compounds.
- Calculate the oxidation number.
- Explain the oxidation and reduction in different reactions.





The modern periodic table

The modern periodic table consists - as shown on the previous page - of :

• 7 periods (horizontal rows).

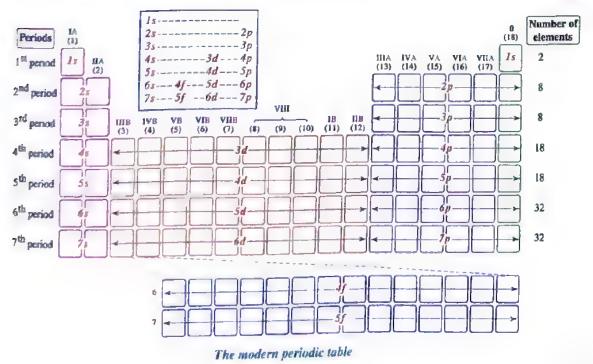
18 groups (vertical columns).

The elements are arranged ascendingly according to:

- Their atomic numbers (number of protons).
- The sequence of filling energy sublevels
 with electrons according to Aufbau (the building-up)
 principle, where each element has one more electron
 than the element which precedes it in the same period.

The atom is electrically neutral (in its elemental state) because number of positive protons equals number of negative electrons





Each period begins by filling a new principal energy level with one electron, then filling the energy sublevels lying in the same principal energy level successively, until we reach the last element in the period which is a noble gas in which all the levels are completely filled with electrons.

Elements of the same group

- * Similar in their chemical properties, as they are similar in the electronic configuration of the last level (the valence shell).
- * Different in the principal quantum number (n) of this outermost energy level.

Elements of the same period

- * Different in their chemical properties, as they are different in the electronic configuration of the last level (the valence shell).
- * Similar in the principal quantum number (n) of this outermost energy level.

Test yourself

The chemical properties are much alike in the two elements

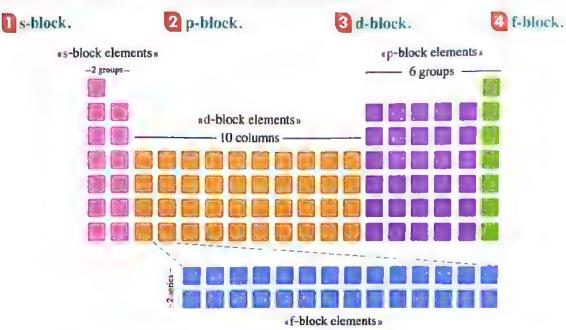
Answer: The correct choice is

* The modern periodic table consists of 118 elements distributed in seven horizontal periods, as follows:

	1		· · · · · · · · · · · · · · · · · · ·	/*************************************	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	Andrewson Andrewson	A
Period	First	Second	Third	Fourth	Fifth	Sixth	Seventh
Number of elements	2	8	8	18	18	32	32
	/		press. New 275- 40-	2.2.2.	***************************************	ļ	

The elements blocks of the modern periodic table

• The table is divided into four main blocks, these blocks are :



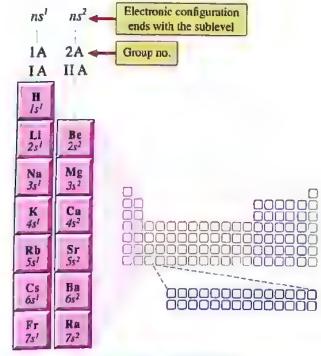
The blocks of the modern periodic table

* Each block of elements in the periodic table contains a number of vertical groups equals the number of the electrons which fill the sublevel of the block.

1 s-b

s-block elements

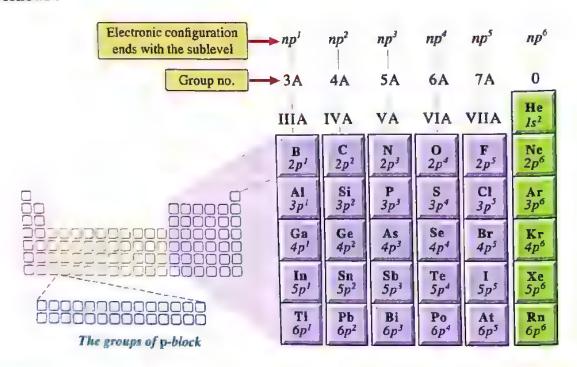
- They are placed in the left side of the table.
- The s-block contains the elements whose outermost electrons occupy the "s" sublevel «except ⁴₂He».
- The s-block consists of two groups of elements, they are:
- 1A whose electronic configuration ends with ns 1
- 2A whose electronic configuration ends with ns²
- Where "n" stands for the number of the outermost energy level as well as the number of the period.



The two groups of s-block

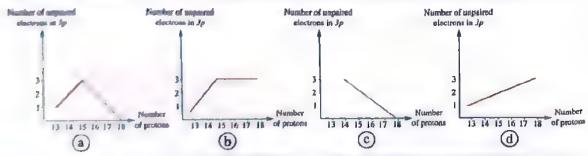
p-block elements

- They occupy the right side of the table.
- The p-block includes the elements whose outermost electrons occupy the "p" sublevel and their electronic configurations end with $(ns^2, np^{1:6})$, (except helium $1s^2$).
- The p-block consists of six groups, characterized by the letter "A" except "group zero", as follows:



Test bourself

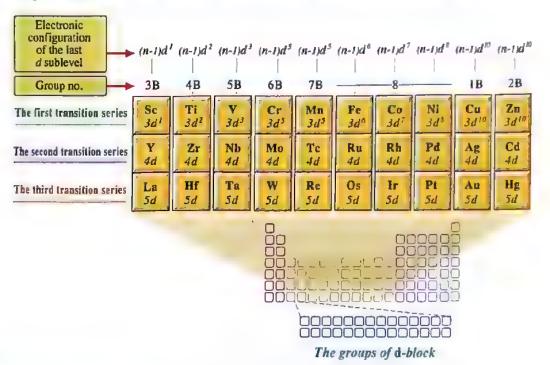
Which of the following graphical figures represents the number of the unpaired electrons in the orbitals of 3p sublevel of some elements of the third period in the periodic table ?



Answer: The correct choice is

3 d-block elements

- They occupy the middle of the table.
- The d-block contains the elements in which the "d" sublevel is filled successively by electrons and their electronic configurations end with $(ns^{1.2}, (n-l)d^{1.10})$.
- The d-block consists of "10" vertical columns representing "8" groups which are characterized by the symbol "B" except eighth group (VIII) which consists of "3" vertical columns.
- The d-block elements are classified according to the number of the outermost energy level and the period number into 4 series (each contains 10 elements), among them are:



The first transition series :

- It includes the elements in which the "3d" sublevel is filled successively.
- It lies in the fourth period and includes the elements from scandium (21Sc) to zinc (30Zn).

1 The second transition series :

- It includes the elements in which the "4d" sublevel is filled successively.
- It lies in the fifth period and includes the elements from yttrium (39Y) to cadmium (48Cd).

The third transition series :

- It includes the elements in which the "5d" sublevel is filled successively.
- It lies in the sixth period and includes the elements from lanthanum (57La) to mercury (80Hg).

Test llourself

Which quantum numbers represent the electrons of the last sublevel that is filled successively in the elements 21Sc to 30Zn?

(a)
$$n = 3, l = 1$$

(b)
$$n = 3$$
, $l = 2$ (c) $n = 4$, $l = 1$

©
$$n = 4$$
, $l = 1$

(d)
$$n = 4$$
, $l = 2$

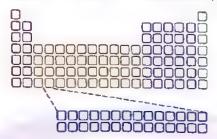
Idea of answering:

: The elements from 21Sc to 30Zn are the elements of the transition series which lies in the period, in this series the sublevel is successively filled with electrons.

Answer: The correct choice is

f-block elements

- They are separated down the table, to avoid being too long.
- In this block the "f" sublevel is filled successively.
- The f-block is divided into two series (each contains 14 elements), which are:





The two series of \(\mathbf{l}\)-block

The lanthanides series:

- It is placed in the sixth period, in which the "4f" sublevel is filled successively, it includes 14 elements.
- The elements of this series were named inaccurately by rare earths .. G.R.? Because they are quite similar in behavior and very difficult to be separated from each other as the outermost energy level for all of them is 6s2 However, that name is not accurate, as recently their oxides could be separated by ionic exchange.

O The actinides series :

- It is placed in the seventh period, in which the "5f" sublevel is filled second it also includes 14 elements.
- All the elements of this series are radioactive (their nuclei are unstable)

Worked Example

What is the block of elements which includes the largest number of elements in the sixth period in the periodic table ?

- (a) s-block.
- b p-block.
- c d-block.
- d) f-block.

Idea of answering : ...

The sixth period includes elements of the blocks s, p, d and f, these blocks are filled successively with electrons as follows:

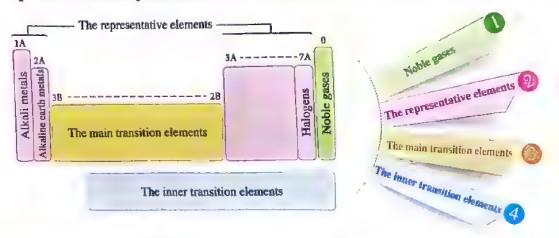
The block	s	p	d	f
The sublevel which is successively filled	s	р	d	f
Number of the orbitals of the sublevel	1	3	5	7
Number of the electrons required to saturate each sublevel	$1 \times 2 = 2e^{-}$	$3 \times 2 = 6e^{-}$	$5 \times 2 = 10e^{-}$	$7 \times 2 = 14e^{-}$
Number of the elements of each block in the sixth period	2	6	10	14

It is shown in the table that the number of the elements of f-block is 14 elements, this is the largest number of elements in the sixth period.

Answer: The correct choice is d

The types of the periodic table elements

• It is possible to classify the elements in the periodic table into four types, which are :



The types of the periodic table elements

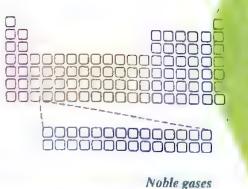
Included information

Some significant groups in the periodic table are named with characteristic names, as in the opposite table:

Number of group	The characteristic name of the group
1A	Alkali metals
2A	Alkaline earth metals
7A	Halogens
0	Noble gases

Noble gases

- They are the elements of group zero "18" which is the last column of p-block.
- They are characterized by having energy levels completely filled with electrons and their electronic configurations end with npb, except that of helium 2He which ends with 1s2



Helium $1s^2$ Neon 25²,2p Argon Krypton 452,4p Xe Xenon Rn Radon

G.R. Noble gases may form compounds, but with great difficulty.

Because they are very stable elements as their energy levels are completely filled with electrons.

100

If the principal quantum number of the last electron in the atom of a noble gas is (n=3). What is the number of the orbitals which are completely filled with electrons in this atom?

(a) 3

b 5

©7

(d) 9

Idea of answering:

- : This element is a noble element.
- : All the energy level in its atom are filled with electrons.
- : The principal quantum number of its last electron is 3
- : The electronic configuration of this atom is : $1s^2$, $2s^2$, $2p^6$, $3s^2$, $3p^6$
- \therefore The number of the filled orbitals = 1 + 1 + 3 + 1 + 3 = 9 orbitals

Answer: The correct choice is (d)

Test yourself

What is the number of the natural noble gase(s) in which Is orbital is filled with electrons?

(a) 1

(b) 3

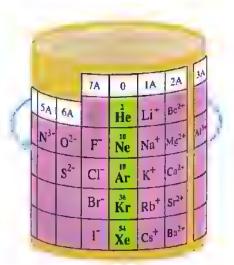
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d 6

Answer: The correct choice is

The representative elements

- They are the elements of s and p-blocks, except that of group zero.
- They occupy the groups from 1A: 7A
- These elements are characterized by the complete filling of all the energy levels with electrons, except for the outermost level.
- They are active elements.. G.R. ? Because their outermost energy level tends to reach the completed electronic configuration similar to that of the nearest noble gas $(1s^2 \text{ or } ns^2, np^6)$ by gaining, losing or sharing electrons.



The representative elements tend to reach the electron configuration of the nearest noble gas

Examples

(Similar to the electronic configuration

of neon gas
$$_{10}$$
Nc)

16S

2 electrons

 $1s^2$, $2s^2$, $2p^6$, $3s^2$, $3p^4$
 $1s^2$, $2s^2$, $2p^6$, $3s^2$, $3p^6$

Representative elements is the topic of Chapter 4 second term

(Similar to the electronic configuration of argon gas 18Ar)

$$_{1}H + _{1}H \xrightarrow{\text{sharing}} H_{2}$$
 $_{1}s^{1} \quad Is^{1}$

(Similar to the electronic configuration of helium gas ₂He)

3 The main transition elements

- They are the elements of the d-block.
- They are characterized by having energy levels completely filled with electrons, except the outermost two levels.

Transition elements
will be thoroughly discussed
next year

- * Example: $_{21}$ Sc: $1s^2$, $2s^2$, $2p^6$, $3s^2$, $3p^6$, $4s^2$, $3d^1$
 - In the principal level (n = 4): The sublevel 4p is vacant.
 - In the principal level (n = 3): The sublevel 3d is incompletely filled.

The inner transition elements

- They are the elements of the f-block.
- They are characterized by having energy levels completely filled with electrons, except the outermost three levels.
- Example: $_{64}$ Gd: Is^2 , $2s^2$, $2p^6$, $3s^2$, $3p^6$, $4s^2$, $3d^{10}$, $4p^6$, $5s^2$, $4d^{10}$, $5p^6$, $6s^2$, $4f^7$, $5d^1$
 - In the principal level (n = 4): The sublevel 4f is incompletely filled.
 - In the principal level (n = 5): The sublevel 5d is incompletely filled.
 - In the principal level (n = 6): The sublevel 6p is vacant.

Test-Hourself-

- (1) What is the type of the element whose atom has an electronic configuration ends with:, $4f^{14}$, $5d^9$, $6s^I$?
 - (a) An inner transition element.
- (b) A main transition element.

(c) A representative element.

(d) A noble element.

Idea of answering:

- : The two outer principal energy levels and are not completely filled with electrons.
- : The element is

Answer : The correct choice is

- (2) What is the total number of the inner transition elements in both the fourth and the fifth periods in the periodic table ?
 - (a) Zero
- (b) 14

© 24

(d) 28

Idea of answering:

- : Inner transition elements start to appear in the period.
- ... Number of the inner transition elements in both the 4th and the 5th periods =

Answer: The correct choice is (a)

The electronic configuration in the light of the modern periodic table

• The periodic table shows a method to express the electronic configurations of the elements according to the nearest noble gas which precedes the element in the periodic table and this is the method of the electronic configuration of elements which was referred to before in Chapter 1

[Is']			2 He
[2s']		2p'	Ne Ne
35'		3p' C1	18 A r
45'	3d Fe	4p'	16 Kr
55'	[4d'] [4d] [Cd]	5p1	34 Xe
6s' Ba	Sd'	6p'	Rn Rn
75	6d'	7p'	

• The following table shows the electronic configurations of the atoms of the illustrated elements in the previous periodic table:

The ordinary electronic configuration	Electronic configuration to the nearest noble gas
$_{17}\text{Cl}: 1s^2, 2s^2, 2p^6, 3s^2, 3p^5$	17Cl:[10Ne], 3s ² , 3p ⁵
26 Fe: Is^2 , $2s^2$, $2p^6$, $3s^2$, $3p^6$, $4s^2$, $3d^6$	26Fe:[₁₈ Ar], 4s ² , 3d ⁶
48 Cd: $1s^2$, $2s^2$, $2p^6$, $3s^2$, $3p^6$, $4s^2$, $3d^{10}$, $4p^6$, $5s^2$, $4d^{10}$	48Cd: [36Kr], 5s ² , 4d ¹⁰
56Ba : $1s^2$, $2s^2$, $2p^6$, $3s^2$, $3p^6$, $4s^2$, $3d^{10}$, $4p^6$, $5s^2$, $4d^{10}$, $5p^6$, $6s^2$	56Ba:[54Xe], 6s ²

Test Yourself-

What is the block of the element whose atom has the electronic configuration :

[Kr], 4d10, 4f4, 5s2, 5p6, 6s2?

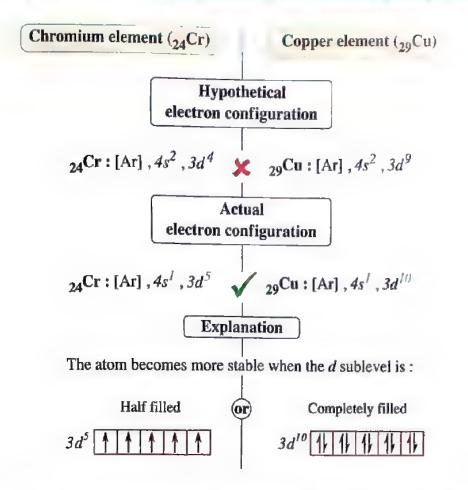
- (a) s-block.
- b p-block.
- © d-block.
- d f-block.

Idea of answering:

- \because In this atom, the sublevel is not completely filled.
- .. The element belongs to block.

Answer: The correct choice is

The anomaly of the electron configurations of some electron.



• By the same way the electronic configuration of both molybdenum (42Mo) and gadolinium (44Gd).

Yesi Yourself

- (1) Give reason : The anomaly of the electron configuration of molybdenum $_{42}{
 m Mo}$, and write its electron configuration.
- (2) Is it possible for the sublevel 3d to contain 5 single (unpaired) electrons in the atom of each of 2 elements both located in 4th period ? Explain your answer.

105 المعاصر كيمياء -لفات (شرح)/ ٢٠ (م: ١٤)

• The following table represents the electron configurations of the atoms of some elements of the modern periodic table in their ground states :

Atomic number	Element	Electron configuration
	н	Is ¹
2	He	$Is^2 = [He]$
3	Li	[He], 2s ¹
4	Ве	[He], 2s ²
5	В	[He], $2s^2$, $2p^l$
6	C	[He], $2s^2$, $2p^2$
7	N	[He], $2s^2$, $2p^3$
8	0	[He], $2s^2$, $2p^4$
9	F	[He], $2s^2$, $2p^5$
10	Ne	[He], $2s^2$, $2p^6 = [Ne]$
11	Na	[Ne], 3s ^I
12	Mg	[Ne], $3s^2$
13	Al	[Ne], $3s^2$, $3p^1$
14	Si	[Ne], $3s^2$, $3p^2$
15	P	[Ne], $3s^2$, $3p^3$
16	S	[Ne], $3s^2$, $3p^4$
17	CI	[Ne], $3s^2$, $3p^5$
18	Ar	[Ne], $3s^2$, $3p^6 = [Ar]$
19	K	[Ar] , 4s ^I
20	Ca	$[Ar], 4s^2$
21	Se	$[Ar]$, $3d^{1}$, $4s^{2}$
22	Ti	[Ar], $3d^2$, $4s^2$
23	V	$[Ar]$, $3d^3$, $4s^2$
24	Cr	$[Ar]$, $3d^5$, $4s^1$
25	Мв	$[Ar]$, $3d^5$, $4s^2$

Atomic number	Element	Electron configuration
26	Fe	[Ar], 3d ⁶ , 4s ²
27	Co	[Ar], $3d^7$, $4s^2$
28	Ni	[Ar], $3d^8$, $4s^2$
29	Cu	[Ar], 3d ¹⁰ , 4s ¹
30	Zn	[Ar], $3d^{10}$, $4s^2$
31	Ga	[Ar], $3d^{10}$, $4s^2$, $4p^1$
32	Ge	[Ar], $3d^{10}$, $4s^2$, $4p^2$
33	As	[Ar], $3d^{10}$, $4s^2$, $4p^3$
34	Se	[Ar], $3d^{10}$, $4s^2$, $4p^4$
35	Вг	[Ar], $3d^{10}$, $4s^2$, $4p^5$
36	Kr	[Ar], $3d^{10}$, $4s^2$, $4p^6$ = [Kr]
37	Rb	[Kr], 5s ¹
38	Sr	$[Kr]$, $5s^2$
39	Y	$[Kr]$, $4d^I$, $5s^2$
40	Zr	$[Kr], 4d^2, 5s^2$
41	Nb	[Kr], 4d ⁴ , 5s ¹
42	Mo	[Kr], $4d^5$, $5s^1$
43	Te	$[Kr], 4d^5, 5s^2$
44	Ru	$[Kr], 4d^7, 5s^1$
45	Rh	[Kr], 4d ⁸ , 5s ¹
46	Pd	[Kr], 4d ¹⁰
47	Ag	$[Kr]$, $4d^{10}$, $5s^{1}$
48	Cd	[Kr], 4d ¹⁰ , 5s ²
49	In	[Kr] $,4d^{10},5s^2,5p^1$
50	Sn	[Kr], $4d^{10}$, $5s^2$, $5p^2$

Determination of element location in the periodic table

• Period number:

It is determined by the highest principal quantum number (n) in the electronic configuration of the element.

Group number and symbol:

They are determined by the type of element as shown in the following table:

Type of element	Block	Electronic configuration	Group number		Group symbol
	s	ns ^{1:2}	The number of electrons of the last sublevel (s)		
Representative	p	ns ² , np ^{1:5}	The sum of the numbers of in the last two sublevels ("Excluding group zo	(A)	
Noble gases	p	np ⁶	Group zero (p sublevel is completely filled with electrons) "In addition to helium 2He"		-
Main transition			The sum of the numbers of ethe last (s) sublevel and the (d) sublevel, as follows:		
	d $ns^{1:2}$ $(n-1)d^{1:10}$	ns ^{1:2}	Total number of electrons of ns , $(n-1)d$	Group	(B)
		$(n-1)d^{1:10}$	3:7	3B:7B	group 8
		8:10	8		
		11	1B		
1			12	2B	

Worked Examples

1 Illustrate the block, type and location of the following elements in the periodic table:

 $(1)_{12}$ Mg

(2) ₃₂Ge

 $(3)_{36}$ Kr

(4) ₂₅Mn

(5) 29Cu

Answer:

	Element	Electron configuration	Block	Type of element	Period number	Group number
(1)	12Mg	[Ne], 3s ²	s	Representative	3	2A (2)
(2)	32Ge	[Ar], $4s^2$, $3d^{10}$, $4p^2$	p	Representative	4	4A (14)
(3)	36Kr	[Ar], $4s^2$, $3d^{10}$, $4p^6$	p	Noble gas	4	zero (18)
(4)	25Mn	[Ar], $4s^2$, $3d^5$	d	Main transition	4	7B (7)
(5)	29Cu	[Ar], 4s ¹ , 3d ¹⁰	d	Main transition	4	1B (11)

A representative element contains four principal energy levels occupied by electrons, the last sublevel has three unpaired electrons.

Determine each of the following:

- (1) The electron configuration of its atom.
- (2) Its atomic number.
- (3) Number of completely filled orbitals in the outermost energy level.
- (4) Number of valence electrons.

Answer:

- (1) [Ar], $4s^2$, $3d^{10}$, $4p^3$
- (2)33
- (3) 1 orbital.
- (4) 5 electrons.

Test Vourself

Two elements (X) and (Z) are located in group 5A, if the element (X) is located in the third period, and the element (Z) is located in the fifth period.

What is the atomic number of the element (Y) which lies between them in the same group ?

- (a) 31
- (b) 32
- © 33
- (d) 34

Idea of answering:

- : Element (X) is located in the third period, and element (Z) in the fifth period.
- : Element (Y) is located in the period.
- : The electronic configuration of the atom of this element is:

: The atomic number of element (Y) = + +

=

Answer: The correct choice is

Multiple choice questions





Modern periodic table

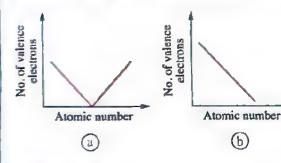
- The elements of the same period are similar in the number of
 - (a) valence electrons.

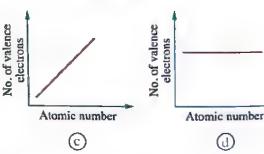
(b) protons.

c energy levels.

(d) neutrons.

2 Which of the following charts represents the relation between the number of valence electrons and the atomic number in the elements of the same group?





Which of the following elements is located in the same period of silicon 14Si in the modern periodic table?

The properties of the two elements are similar.

5 The element whose atomic number is 7 has similar properties to those of the element with the atomic number

a 8

(b) 15

© 19

(d) 21

The chemical properties of both cesium 55 Cs and element X are similar. What is the electron configuration of element X?

(a) Is^l

(b) [Xe], $6s^2$

(c) [Ar] , 3d5 , 4s1

(d) [Ar], $3d^{10}$, $4s^2$, $4p^6$, $5s^4$

110

	of the periods in the p			
the periods of hydr	ogen element (₁ H) and	_		
a zero.	(b) I period.	© 2 periods.	(d) 3 periods.	
The elements bloci	ks of the modern period	lic table		
The molecule of the	e element whose electr	onic configuration e	ends with np^6	
consists of				
a one atom.	(b) two atoms.	© three atoms.	d four atoms.	
The element which	is located at the top ri	ght of the modern p	eriodic table	
is a				
a representative ele	ement.	b noble element.		
© main transition e	lement.	d metallic elemen	nt.	
What is the type of	the elements whose la	st electronic config	uration is : $ns^{1:2}$, np^{1}	
(a) Representative.		(b) Main transition	1.	
© Inner transition.		d Noble.		
What is the atomic	number of the last ele	ment in d-block eler	nents which is locate	
in the fourth period	1?			
a 21	ⓑ 29	© 30	(d) 36	
What is the electro	nic configuration of the	e elements of the pe	enultimate column of	
d-block?				
\bigcirc $(n-1)d^{I}$, ns^{I}	\bigcirc $(n-2)d^1$, ns^1	\bigcirc $(n-1)d^2$, ns^2	$ (1)d^{10}, ns^1 $	
The elements which	ı follow neon gas ₁₀ Ne	and precede rubidio	um element ₃₇ Rb are	
located in				
(a) the third period of	only.	(b) the fourth period	od only.	
the third and the fourth periods.		d the fourth and the fifth periods.		
What is the number	of the elements of f-b	lock ?		
3 32	(b) 46	© 28	(d) 14	
) J <u>.</u>	U 40	(J) 20	9 -	
		ette i tal- Landauma	e in the caries	
	I which is successively	filled with electron	a III riie zenez	
What is the subleve of actinides?	l which is successively	filled with electron:	s III tile selles	

16	Which of the following elements the electronic configuration of	f its valence shell
	differs from those of the other elements that are located in the	same group ?

(a) 36Kr

(b) 19K

© Be

 $(d)_{2}$ He

The types of the periodic table elements

What is the type of the element which the last electron in its atom has the two quantum numbers $(\ell = 1, m_s = +\frac{1}{2})$?

(a) Representative only.

(b) Noble only.

(c) Representative or noble.

(d) Representative or main transition.

18 Which of the following choices represents the electron configuration of an alkaline earth metal?

(a) [Ar], $4s^{1}$, $3d^{5}$

(b) [Ar], $4s^2$, $3d^6$

 \bigcirc [Rn], 7s²

(d) [Xe], $6s^2$, $5d^1$, $4f^7$

19 Which of the following choices represents the electron configuration of a transition element?

(a) $1s^2$, $2s^2$, $2p^6$, $3s^2$, $3p^6$, $3d^{10}$, $4s^2$, $4p^6$

(b) $1s^2$, $2s^2$, $2p^6$, $3s^2$, $3p^6$, $3d^{10}$, $4s^2$, $4p^1$

© $1s^2$, $2s^2$, $2p^6$, $3s^2$, $3p^6$, $4s^2$, $3d^2$

(d) $1s^2$, $2s^2$, $2p^6$, $3s^2$, $3p^6$, $4s^2$

Actinides are similar to lanthanides in

(a) the successive filling of 4f sublevel.

(b) the instability of their nuclei.

(c) that it is impossible to determine the numbers of their groups.

(d) their location in the sixth period.

What is the difference in the number of the representative elements found in the second period from those found in the third period?

(a) 0

© 8

(d) 10

Which of the following types of elements constitutes the largest number of elements in the fourth period?

(a) p-block elements.

(b) Representative elements.

Main transition elements.

(d) Metals.

The electronic configuration in the light of the modern periodic table

Each of the electron configurations in the table represents the mentioned type of elements, except

Choices	Electron configuration	Type of elements
(a)	$ns^{1:2} \approx ns^2, np^6$	Representative
Ъ	$1s^2 \approx ns^2, np^6$	Noble gas
0	$(n-1)d^{1:9}$, ns^{1} or 2	Main transition element
(1)	$(n-2)f^{1:14}$, $(n-1)d^{1}$ or 0 , ns^{2}	Inner transition element

- All the following are among the properties of the elements ₄Be , ₁₂Mg and ₂₀Ca , except that
 - (a) the last sublevel s contains 2 electrons.
 - (b) the sublevel p in the valence shell contains a pair of electrons.
 - (c) they are all representative elements.
 - d they are all located in group (2A).
- What is the type of the element which contains 1 electron in the sublevel whose quantum number (ℓ) is 2?
 - (a) Main transition.

(b) Inner transition.

© Noble.

- d Representative.
- What is the type of the element whose electronic configuration

is: [Ar], $4s^2$, $3d^{10}$, $4p^1$?

- (a) Main transition element.
- (b) Inner transition element.
- © Representative element.
- d Noble element.
- The element whose electron configuration is : [Xe], $6s^2$, $4f^3$ belongs to
 - (a) the third main transition series.
 - b lanthanides.
 - © the second main transition series.
 - d actinides.

28 The following diagram shows a section in the modern periodic table:

Li	Be										o	F	Ne
Na	Mg										S	CI	Аг
K	Ca	V	Cr	Mn	Fe	Co	Ni			As	Se	Br	Kr

What is the number of each of the representative and the transition elements which are mentioned in this section?

- (a) 16 representative and 6 transition.
- (b) 13 representative and 6 transition.
- © 6 representative and 8 transition.
- (d) 10 representative and 12 transition.
- The electronic configuration of silver 47Ag is

(a) [Ar],
$$4s^2$$
, $4d^9$

(b) [Kr],
$$5s^{1}$$
, $4d^{10}$

© [Kr],
$$5s^2$$
, $3d^9$

(d) [Ar],
$$4s^{1}$$
, $4d^{10}$

M An element with atomic number 42, the number of its half filled orbitals is

31 There is an anomaly in the electronic configuration of each of

The two electron configurations are similar in

What is the correct order which represents the number of the unpaired electrons in the ions of these transition elements?

$$[{}_{24}\mathrm{Cr}\,,{}_{26}\mathrm{Fe}\,,{}_{28}\mathrm{Ni}\,,{}_{29}\mathrm{Cu}\,]$$

(a)
$$Cu^{2+} > Ni^{2+} > Cr^{3+} > Fe^{3+}$$

(b)
$$Cr^{3+} > Fe^{2+} > Ni^{2+} > Cu^{2+}$$

©
$$Fe^{3+} > Cr^{3+} > Cu^{2+} > Ni^{2+}$$

①
$$Fe^{3+} > Cr^{3+} > Ni^{2+} > Cu^{2+}$$

Ine electron configuration of ruthenium ion 44Ru3+ is

(a) [Kr],
$$4d^3$$
, $5s^2$

(b) [Kr],
$$4d^6$$
, $5s^2$

S Which of the	following represents t	he location of the ele	ement 73X in the mode	
periodic tabl	le ?			
3 5th period	, group 7	6th period	group 13	
© 6 th period	, group 5	(d) 5 th period	, group 5	
Which of the	following statements r	epresents properly t	he element which is lo	cated
in period 3,	group (VIIA) in the mo	dern periodic table ?		
a It forms a	n ion whose charge is +1			
b It is one of	of d-block elements.			
(c) Its valence	e shell contains 5 electro	ns.		
d It is a repr	resentative element whic	h is located below flu	orine ₉ F	
What is the	electron configuration o	of the ion of the elem	ent which lies in	
the 4 th perio	d, group 2A in the perio	odic table ?		
(a) [Ne], 3s ²	$,3p^{6}$	(b) [Ar], 4s ²		
© [Ne], 4s2	$,4p^{4}$	\textcircled{d} [Ar], $4s^2$	$,4p^{6}$	
38 The electron	configuration of the io	n X $^{3+}$ ends with : $6s^0$	$,4f^{14},5d^{8}$	
The element	X lies in group	••		
a 8	ⓑ 10	© 11	d 9	
The electronic	c configuration of the ou	iter energy levels in t	he element which lies i	n
the period (n	a) and group (5B) is	******		
ⓐ ns^2 , $(n-2)$	$f^{14}, (n-1)d^5$	(b) ns^2 , $(n-1)$	$(1)f^{14}, (n-1)d^3$	
\bigcirc ns^2 , $(n-2)$	$f^{14},(n-I)d^3$	\bigcirc ns^2 , $(n-2)$	$!)f^{14}$, nd^3	
The element	whose electronic config	guration ends with :	$ns^I, (n-I)d^5$ and its ele	ctrons
, are distribute	ed in 5 principal energy	levels has the atomi	c number	
a 29	(b) 24	© 47	d 42	
What is the management	naximum number of orb	itals that can be occ	upied by electrons in e	ach
of the atoms	of the elements of 6 th j	period in which the e	lectron has the quantu	m
number (m/	= +3) ?			
(a) 1	(b) 3	© 5	① 7	
				115

- What is the number of the half filled orbitals in the atom of the divalent representative element which is located in p-block in the periodic table?
 - (a)]

- **b** 2
- © 3
- **d** 4
- What is the type of the divalent element whose ion has the electron configuration : [Ar]?
 - (a) Main transition.

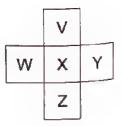
(b) Inner transition.

© Inert.

- d Representative.
- An element is located in the third period, if its atom gains two electrons, then its last sublevel becomes completely filled with electrons.

What is the symbol of this element?

- (a) 13Al
- ы
- © 15P
- (d) 16S
- What are the possible quantum numbers of the last electron in the atom of an element which is located in the fourth period, group (7A)?
 - (a) n = 4, l = 1, $m_l = 0$, $m_s = -\frac{1}{2}$
 - (b) n = 4, l = 1, $m_l = -1$, $m_s = -\frac{1}{2}$
 - © n = 4, l = 2, $m_l = -1$, $m_s = +\frac{1}{2}$
 - (d) n = 3, l = 0, $m_l = 0$, $m_s = +\frac{1}{2}$
- The shown diagram expresses a part in the modern periodic table : If the electron configuration of the element W ends with $3p^2$ Which of the following describes one of the shown elements ?



- (a) Element V is representative and lies in group 3A
- (b) Element X lies in 3rd period, group 5A
- © Element Y is a noble gas and lies in 3rd period.
- d Element Z lies in 4th period, group 3A
- Three elements (A, B, C) are located in one period in 3 consecutive groups, the element (A) lies in the beginning of the third period, so the electron configuration of element (C) ends with
 - (a) 4s1

- ⓑ *3p³*
- (c) 3d1
- (d) $3p^{I}$

The electrons of the atom of a representative element occupy 3 principal energy levels, and its last sublevel contains a number of electrons double their number in its first principal level.

What is the atomic number of this element?

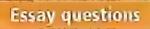
(a) 34

- **b** 33
- © 32
- (d) 31
- If the electronic configuration of an element atom is : [Xe], $6s^2$, $5d^4$, $4f^7$ Which of the following choices represents the distribution of the electrons in the principal energy levels ?
 - (a) 2 -8 -18 -32 -4

(b) 2 -8 -18 -18 -8 -2

(c) 2-8-18-25-9-2

(d) 2-8-18-32-4





- Give reason:
 - (1) The elements of the same group are similar in the chemical properties.
 - (2) Molybdenum element 42 Mo has an anomalous electronic configuration.
- Demonstrate the similar electronic configuration of the ions of zinc 30Zn and copper 29Cu
- 2 The following diagram represents a section in the modern periodic table :



Conclude the difference between the atomic numbers of the two elements U and T, with explanation.

- S An element (X) its electronic configuration ends with $5s^2$, $4d^1$:
 - (1) What is the type of this element?
 - (2) Determine the location of this element in the periodic table.
 - (3) What is the number of the protons inside the nucleus of the atom of this element?
- The electrons of the representative element (M) are distributed in 2 principal levels, and its last sublevel contains 3 unpaired electrons:
 - (1) Determine the location of this element in the periodic table.
 - (2) What is the block of this element?

Determine the block and the type of the elements which have the following electronic configurations:

(1) [Ar], $4s^2$, $3d^5$

(2) [Xe], $6s^2$, $4f^7$, $5d^1$

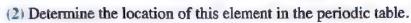
Illustrate the electronic configuration of each of the following elements, with writing their atomic numbers :

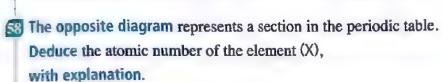
(1) A representative element which is located in period 2, group 5A

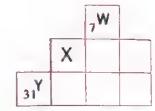
(2) A noble element located in period 3

The opposite figure illustrates the atom of one of the elements :

(1) Write the electronic configuration of this element atom according to the nearest noble gas.





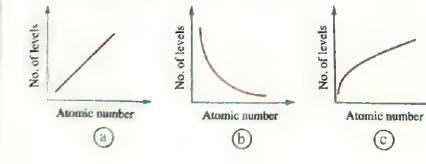


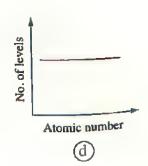
Predict the general formula of the oxides of the representative elements of group (2A).



Choose the correct answer:

Which of the following charts represents the relation between the number of principal energy levels occupied by electrons and the atomic number of the elements in the same vertical group in the periodic table?





What is the compound in which the number of electrons of its positive ion equals the number of electrons of its negative ion?

[Na = 11], Mg = 12], Cl = 17], S = 16 | O = 8]

MgCl,

(b) NaCl

(3) MgO

- (I) MgS
- - (a) IIIA

(b) **IA**

() IVA

- (d) VIIA
- The electron configuration of the positive ion of the compound MO ends with the sublevel $2p^6$

Which of the following determines the period and the group of element M in the modern periodic table?

- 4th period, group 7
- 6 4th period, group 9
- 3rd period, group 16
- 3rd period, group 2
- 🍒 If the four quantum numbers of the electron with the highest energy in the atom of a main transition element located in the period (X) are $(3, 2, +2, +\frac{1}{2})$, then the probable four quantum numbers of the last electron in the representative element which is located at the end of the period (X) are

$$94,1,0,-\frac{1}{2}$$

$$93,1,+1,+\frac{1}{2}$$

$$94.0,0,+\frac{1}{2}$$

$$3.2,+2,-\frac{1}{2}$$

Choose the correct answ	ver for the questions 11: 9
1 The maximum number of	f electrons can be found in an atom that has the following
quantum numbers (n = 3	, (= 1) is
a 18	(b) 7
© 3	(d) 6
2 The last sublevel in (X ⁺)	ion is $2p^6$
What is the number of the	he half filled orbitals in the atom (X)?
② zero	b 1
© 2	(d) 3
3 What is the type of the	element which contains 5 electrons in the sublevel whose
value of the subsidiary of	quantum number ($l=1$) ?
Main transition.	
(b) Inner transition.	
© Representative.	
(d) Noble.	
What is the atomic num	ber of the atom whose orbitals contain three unpaired
electrons ?	
a 5	ⓑ 13
© 15	d 21
S What is the number of o	orbitals which are completely filled with electrons in
the principal level (n = 3	3) of ₁₅ P?
a 1	(b) 3
© 6	(d) 9
6 The number of orbitals	of the principal level (n) equals
	(h) 9

(d) 16



_	Test on the Second mo
(The electron which has magnetic quantum number ($m_{\ell} = -3$) may has the principa
1	quantum number
i	\bigcirc n = 3
	Which of the following combinations of the quantum numbers doesn't include
	a mistake ?
	(a) $n = 2$, $l = 2$, $m_l = +1$
Ì	(b) $n = 2$, $l = -1$, $m_l = 0$
	© $n = 3$, $l = 2$, $m_l = +3$
	(d) $n = 4$, $l = 3$, $m_l = -2$
	The number of electrons present in orbitals of (p) sublevels is smaller than
	the number of electrons in (s) sublevels in
	② ₁₂ Mg
1	(b) No

the numb	er of electrons in (s) sublevels in
ⓐ ₁₂ Mg	
Б 11 Na	
© ₇ N	

(d) ₁₃AI

Answer the essay questions 10: 12

C	Write the electronic configuration of (24X) then
1	Determine which block it belongs to.
	· ·····
1	***************************************

المعاصر كيمياء لفات (شرح) / ٢٠ (م: ١٦)



Write the chemical formula for a compound formed from (X) and (Y) elements the quantum numbers of the last electron of each of them are:

	n	l	m _l	m _s
(X)	2	1	-1	$-\frac{1}{2}$
(Y)	3	0	0	+ 1/2

************	****************		************	.,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	************		
***************************************		***************************************	************			***************************************	

(12	A representative element contains three principal energy levels and the last energy	jy
	sublevel contains three unpaired electrons.	

Calculate:

1) The number of orbitals which are con	npletely filled with electrons.
	,
(2) The atomic number.	
***************************************	*** ***********************************

on the Second month

Choose t	he	correct	answer	for	the	questions
CHOOSE I	· HAVE	COLLEGE				all and realizable





<u>except</u>

(a)
$$n = 2$$
, $l = 2$, $m_l = +1$

(b)
$$n = 2$$
, $l = -1$, $m_l = 0$

①
$$n = 3$$
, $l = 2$, $m_l = +3$

(d)
$$n = 4$$
, $l = 3$, $m_l = -2$

,		
1	with the state of the state of the same of	7
11	 . Which of the following cliblevels can ansorbs a proton out califol luse vile	5
11	Which of the following sublevels can absorbs a photon but cannot lose one	

(a) 3d

(b) 2p

© 1s

(d) 2s

The elements tend to reach the electron structure:
$$ns^2$$
, np^6

- (a) noble
- **b** representative
- © main transition
- d inner transition

a 3

b 4

© 5

d 6

$lue{0}$ The electron configuration of the element (X) ends with :

$$(n-1)s^2$$
, $(n-1)p^6$, $(n-1)d^5$, ns^2 ,

if n = 4 then the atomic number of (X) is

② 15

(b) 35

© 30

(1) 25

Which of these ions its el	ectron configuration is not similar to that of a noble gas ?
(a) CIT	(b) Rb ⁺
⊙ Sn ²⁺	\bigcirc Mg^{2+}
What is the number of el	ements in which the orbitals of 3d sublevel contain
one single (unpaired) ele	ctron or more in the ground state ?
3 7	(b) 8
© 9	d 10
8 What is the maximum nu	mber of electrons which have the spin quantum number
$(\mathbf{m}_{s} = +\frac{1}{2})$ in the subleve	$el(\ell=3)?$
(a) 3	(b) 5
⊙ 6	(d) 7
What is the number of el	ectrons which have the quantum numbers $(n = 3)$, $(l = 2)$
in iron atom ?	
② 2	(b) 4
© 6	(d) 8
Answer the essay question	s 10 : 12
	gurations of elements 47Ag and 35Br then
Locate the position of the	ses elements in the periodic table.

	Test on the Second month
(n)	Why is it difficult to obtain M ²⁺ ion from the element which is located in
	the third period, group (1A).
	.,,
12	Mention the four quantum numbers for the last electron which has the highest energy
	in the following elements: 15P and 29Cu
f	

Test 3





Choose the correct answer for the questions 11: 9





(a) Fe

(b) Fe⁴⁺

© Fe²⁺

(d) Fe³⁺

Which of the following quantum numbers include a mistake?

- (a) n=2, l=1, $m_l=+1$
- (b) n=4, l=2, $m_l=+1$
- (c) n = 3, l = 3, $m_l = -2$
- (d) n = 3 , l = 0 , $m_l = 0$

According to Hund's rule and Pauli's exclusion principle, the last two electrons in 3d sublevel in the atom of element 26X are different in the two quantum numbers

- (a) l and m,
- (b) n and m₁
- (c) l and m
- d m, and m,

What is the compound in which the number of electrons of its positive ion equals the number of electrons of its negative ion?

(a) MgCl₂

(b) NaCl

(MgO

(d) MgS

What is the electronic configuration which represents an excited atom?

- (a) $_{9}F: 1s^{2}, 2s^{2}, 2p^{5}$
- \bigcirc ₇N: $1s^2$, $2s^2$, $2p^3$
- \bigcirc He: Is^2
- ① $_{3}\text{Li}: Is^{2}, 2p^{I}$

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What is the maximum nu	umber of electrons which can be found in the setting of the
and have the two quanti	um numbers ($n = 4$, $l = 1$)?
(a) 2e ⁻	(b) 6e
© 8e ⁻	(d) 10e ⁻
The two orbitals $2s$, $2p_x$	can be similar in
a) the energy.	
(b) the shape.	
© the number of electron	ns in each of them.
d the spatial orientation.	
What is the number of e	lectrons of the last principal energy level of the element
which contains 15 compl	letely filled and 2 half filled orbitals?
(a) 2e ⁻	ⓑ 3e ⁻
© 4e ⁻	(d) 5e ⁻
What is the number of el	lectrons which have magnetic quantum number
$(m_{\ell} = 0)$ in cobalt (II) ior	1 ₂₇ Co ²⁺ ?
△ 7e ⁻	(b) 8e ⁻
○ 10e ⁻	(d) 11e ⁻
Answer the essay questions	s (10 : 12
Verify Pauli's principle on	the two electrons of the last orbital of chloride ion 17Cl
* == ,	***************************************



- The bond length in hydrogen molecule $H_2 = 0.6 \text{ Å}$
- The bond length in nitrogen molecule $N_2 = 1.4 \text{ Å}$
- The bond length in nitric oxide molecule NO = 1.36 Å

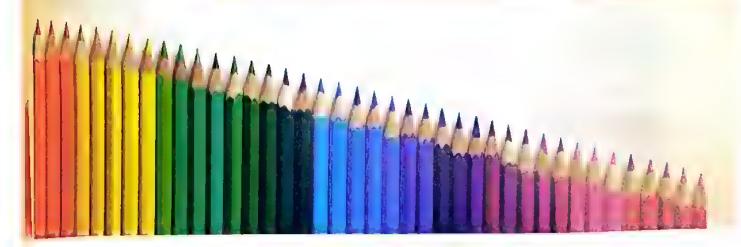
Calculate:

(1) The bond length in	oxygen molecule O ₂
------------------------	--------------------------------

(2) The bond length (O-H) in water molecule H₂O

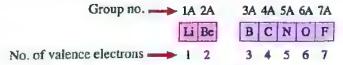
(B)	Write the four quantum numbers of electron number 11 in each of sodium and
ŧ	magnesium atoms.
Ш	

Chapter 2
Lesson Two



The graduation of the representative elements properties

The chemical properties and some of the physical properties of the elements depend on their electronic configurations and especially on the valence electrons (the electrons which are found in the outermost principal level).



The numbers of the valence electrons of the elements in the second period

We will study the graduation of the following properties in the representative elements:

- The atomic radius.
- 2 Ionization potential.
- 3 Electron affinity.
- Electronegativity.
- Metallic and nonmetallic property.
- Acidic and basic property.
- Oxidation numbers.

The atomic radius



- The concept of bond length in the covalent compounds differs from that in the ionic compounds.
- By knowing the bond length, we can calculate:
 - Atomic radius.

B Ionic radius.

Atomic radius

 The atomic radius cannot be estimated or measured physically by the distance between the nucleus and the farthest electron ... G.R.?

Because it is impossible to determine the precise location of an electron around the nucleus (as the wave mechanics theory revealed).

But the atomic radius can be calculated by knowing the covalent bond length which is estimated in angstroms (Å).

1 angstrom = 1×10^{-10} meter

Covalent bond length (2r)

is estimated by the distance between the centers of the two nuclei of two bonded atoms.

Atomic radius (r)

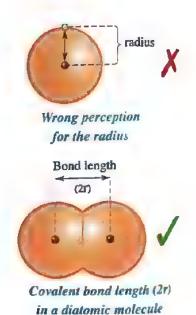
is estimated by half the distance between the centers of two similar atoms in a diatomic molecule.

Covalent bond length = Sum of the two atomic radii of the two atoms of the molecule

The atomic radius (r) = $\frac{\text{Bond length in a diatomic element molecule (2r)}}{2}$

The following table shows the bond length and the covalent atomic radius for some molecules:

The molecule	H-H	F - F	CI-CI	Br - Br	1-1
The bond length (Å)	0.6	1.28	1.98	2.28	2.66
The covalent atomic radius (Å)	0.3	0.64	0.99	1.14	1.33



Worked Examples

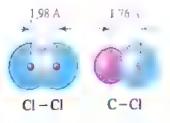
Olf you know that:

- ${\scriptstyle \bullet}$ The bond length in chlorine molecule ${\rm Cl_2}$ is $1.98~{\rm \AA}$
- The bond length between carbon and chlorine atoms

(C – CI) in carbon tetrachloride CCI_4 is 1.76 Å



- (a) 0.22 Å
- **(b)** 0.77 Å
- © 0.99 Å
- d) 1.21 Å



Idea of answering:

The atomic radius of chlorine = $\frac{\text{Bond length in chlorine molecule } \text{Cl}_2}{2}$

$$r(Cl) = \frac{1.98}{2} = 0.99 \text{ Å}$$

The atomic radius of carbon = The (C - Cl) bond length - The atomic radius of chlorine

$$r(C) = 1.76 - 0.99 = 0.77 \text{ Å}$$

Answer: The correct choice is (b)

- \odot The bond length in hydrogen molecule $H_2 = 0.6 \text{ Å}$
 - The bond length in oxygen molecule ${\rm O_2} = 1.32~{\rm \AA}$
 - \bullet The bond length in nitric oxide molecule NO = 1.36 $\mbox{\normalfont\AA}$

Calculate:

- (1) The bond length in nitrogen molecule N_2
- (2) The bond length (N-H) in ammonia molecule NH_3

Answer -

(1) The atomic radius of oxygen = $\frac{\text{Bond length of O}_2 \text{ molecule}}{2}$

$$r(O) = \frac{1.32}{2} = 0.66 \text{ Å}$$

The atomic radius of nitrogen = The (N-O) bond length - The atomic radius of oxygen

$$r(N) = 1.36 - 0.66 = 0.7 \text{ Å}$$

The bond length in nitrogen molecule $N_2 = 2 \times \text{The atomic radius of nitrogen}$

$$2r(N_2) = 2 \times 0.7 = 1A \text{ Å}$$

(2) The atomic radius of hydrogen = $\frac{\text{Bond length of H}_2 \text{ molecule}}{2}$

$$r(H) = \frac{0.6}{2} = 0.3 \text{ Å}$$

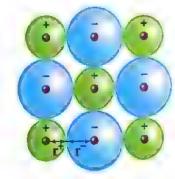
The bond length (N - H) = The atomic radius of nitrogen + The atomic radius of hydrogen

$$r(N) + r(H) = 0.7 + 0.3 = 1 \text{ Å}$$

B Ionic radius

The ionic compounds such as sodium chloride are found in a crystalline form and consist of positive ions (cations) and negative ions (anions).

lonic bond length is estimated by the distance between the centers of the nuclei of two bonded ions in the formula unit of the crystal.



Ionic bond length sum of the radii of (cation + anion)

The ionic bond length = The sum of two ionic radii in the formula unit

• The ionic radius depends on the number of electrons lost or gained to form ions.

Worked Example

- The ionic radius of lithium $(Li^+) = 0.68 \text{ Å}$
- The ionic radius of sodium (Na $^+$) = 0.98 Å
- The bond length of sodium chloride formula unit (Na $^+$ Cl $^-$) = 2.76 Å

What is the ionic bond length in lithium chloride formula unit?

- (a) 1,66 Å
- (b) 1.78 Å
- © 2.08 Å
- @ 2.46 Å

Idea of answering:

• The ionic radius of chloride ion Cl = The (Na+Cl-) bond length - The ionic radius of sodium

$$r(CI) = 2.76 - 0.98 = 1.78 \text{ Å}$$

• The bond length in lithium chloride formula unit (Li+Cl-) =

The ionic radius of lithium ion + The ionic radius of chloride ion

$$r(Li^+) + r(Cl^-) = 0.68 + 1.78 = 2.46 \text{ Å}$$

Answer: The correct choice is (d)

The effective nuclear charge concept (Z-effect)

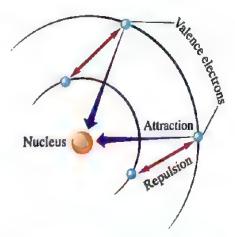
- * The valence electrons are not affected by the complete nuclear charge (the charge of the nucleus protons).
- This is because the inner electrons (core electrons of the inner completely filled energy levels) screen a part of this charge from the valence electrons (electrons of interest).

 Hence, the actual charge affecting any electron is called

the effective nuclear charge (Zeff)

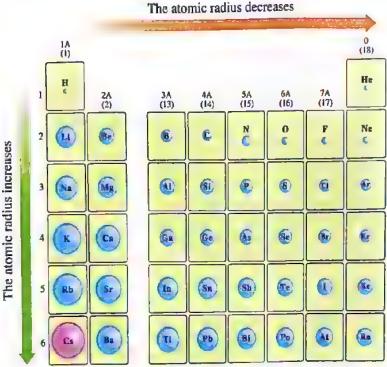
which is the actual nuclear charge (positive charge) that affects an electron in an atom.

And the effective nuclear charge (Z_{eff}) is always less than the nuclear charge (the total number of protons present in a nucleus).



The attraction and repulsion forces which affect the valence electrons

The graduation of atomic radius in the periodic table



The graduation of atomic radius property in the elements
of the two blocks s and p

t It can be observed in the figure that:

In the horizontal period

The atomic radius decreases as we go from left to right across the same period by increasing the atomic number from 1A to group zero

In the vertical group

The atomic radius increases as we go down the same group by increasing the atomic number from the first to the seventh period

Because the increase in the atomic number results in

The gradual increase in the effective nuclear charge ($Z_{\rm eff}$) which increases the nuclear attraction to the valence electrons (pulling them closer to the nucleus) leading to the decrease in the atomic radius.

- The increase in the number of the energy levels in each new period.
- The increase in the number of the completely filled energy levels that screen more of the effective nuclear charge from the outer electrons.
- Increasing the repulsive forces between electrons.

General conclusion:

- The atoms of the first group elements (alkali metals) are the biggest atoms, while the atoms of the seventh group elements (halogens) are the smallest atoms.
- The biggest element atom in size is cesium (Cs),

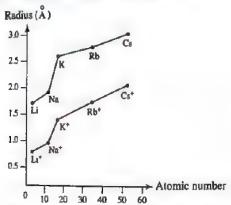
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The relation between the radii of atoms and their ions

* The radii of atoms differ from the radii of their ions as shown in the following .

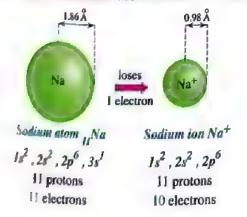
Metals

* The metal atoms tend to lose their valence electrons during the chemical reaction to form positive ions.



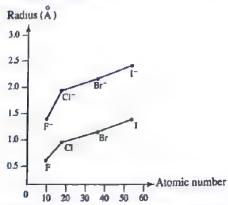
The relationship between metals radii and their positive ions

- The positive ion (the cation) radius is smaller than the radius of its atom... G.R.? As the number of positive protons in the cation is higher than the number of negative electrons. So the attraction of the effective nuclear charge to remaining electrons increases leading to decreasing the size.
- The sodium metal tends to lose its valence electron during chemical reactions to form sodium ion with a radius smaller than the radius of its atom.



Nonmetals

 The nonmetal atoms tend to gain electrons during the chemical reaction to form negative ions.

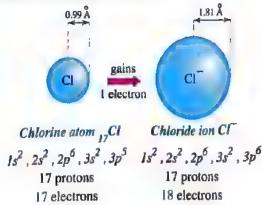


The relationship between nonmetals radii and their negative ions

• The negative ion (the anion) radius is larger than the radius of its atom... G.R.?

As the number of negative electrons in the anion is higher than the number of positive protons. So the repulsive forces between electrons increase due to increasing the number of electrons without any increase in the effective nuclear charge leading to increasing the size.

 The chlorine nonmetal tends to gain an electron during chemical reactions to form chloride ion with a radius larger than the radius of its atom.



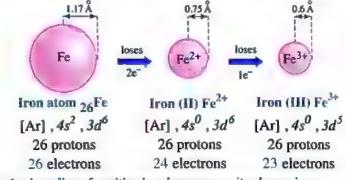
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Worked Examples

Arrange the following species descendingly according to the radius ($Fe^{2+}/_{26}Fe^{-}e^{3+}$), with explanation.

Answer:

The atomic radius of iron atom ($_{26}$ Fe) > The ionic radius of iron (II) ion Fe²⁺ > The ionic radius of iron (III) ion Fe³⁺, because the atomic radii of metals are larger than the radii of their ionic. As the ionic radius of the positive ion decreases, when its charge increases.



Ionic radius of positive ion decreases as its charge increases

- - (a) the size.

(b) the charge of the nucleus.

c the radius.

d the number of the electrons.

Idea of answering:

- : The radius (and hence the size) of the positive ion is smaller than that of its atom.
- .. The choices (a) and (c) are excluded.
- : The number of the electrons of the positive ion is lower than the number of the electrons of its atom.
- :. The choice d is excluded.
- : The number of the protons inside the nucleus of the atom does not change during the formation of the ion.
- .. The charge of the nucleus remains the same.

Answer: The correct choice is (b)

Test Vourself

What happens on moving down the group of halogens from fluorine to iodine?

- (a) The ionic radius increases.
- (b) The atomic number of the halogen decreases.
- © The atomic radius decreases.
- d The number of the valence electrons in the halogen atom increases.

Answer: The correct choice is

Worked Example

Arrange the opposite ions descendingly according to their radii.

$$12^{\text{Mg}^{2+}}$$
 $19^{\text{K}^{+}}$ $33^{\text{As}^{3-}}$ 35^{B}

Idea of answering:

It is clear from the electron configurations of the atoms of these elements that 3 of them are located in the same period (the fourth).

: Atomic radii of the elements of the same period decrease with increasing the atomic numbers.

$$\therefore {}_{19}K > {}_{33}As > {}_{35}Br$$

Element	Electron configuration	Period	Karen ja	
12Mg	[Ne], 3s ²	The third	2A	
19K	[Ar], 4s ¹	The fourth	1A	
33As	$[Ar], 4s^2, 3d^{10}, 4p^3$	The fourth	5A	
35 Br	$[Ar], 4s^2, 3d^{10}, 4p^5$	The fourth	7A	

- .. The radius of the positive ion is smaller than that of its atom, and the radius of the negative ion is larger than that of its atom.
- $:_{33}As^{3-}>_{35}Br^{-}>_{19}K^{+}$
- The ionic radius of 12 Mg²⁺ is smaller than that of 11 Na⁺, as each of these elements is in the same period.
- : The ionic radius of 11 Na⁺ is smaller than that of 19 K⁺, as these two elements are in the same group.

$$:_{19}K^{+} > _{12}Mg^{2+}$$

Answer:

The correct descending order of the radii of the ions is: $_{33}As^{3-} > _{35}Br^{-} > _{19}K^{+} > _{12}Mg^{2+}$

fonization potential (Ionization energy)

If an amount of energy is supplied to an atom — when being in the gaseous state — electrons may be excited and transferred to higher energy levels, but if a sufficient amount of energy is supplied, the most loosely bound electron will be completely removed, giving a positive ion. The minimum amount of this energy is called ionization potential.

• ΔH of the ionization process has a positive sign.. G.R.?

Because the ionization energy is an absorbed energy.

Na_(g) + Energy
$$\longrightarrow$$
 Na_(g) + e⁻ , Δ H = +496 kJ/mol [Ne] , $3s^I$

المعاصر . كيمياء ، نغاث (شرح) / لاث (م: ١٨)

• The atom of the same element has more than ionization energy as shown in following:

First ionization potential	Second Ionization potential	Third lonization totential
Is the amount of energy required to remove an electron which is most loosely bound to the nucleus in an isolated gaseous atom	Is the amount of energy required to remove an electron from a positive ion carries one positive charge	Is the amount of energy required to remove an electron from a positive ion carries two positive charges
M _(g) + Energy —→	M _(g) + Energy —	M _(g) ²⁺ + Energy ——
$M_{(g)}^{+} + e^{-}, \Delta H = (+)$		$M_{(g)}^{3+} + e^-, \Delta H = ($
This leads to the formation of an ion which carries one positive charge	This leads to the formation of an ion which carries two positive charges	This leads to the formation of an ion which carries thre positive charges

Worked Example

in terms of the following equations:

(1)
$$Na_{(g)} \longrightarrow Na_{(g)}^+ + e^- \qquad \Delta H = w$$

(2)
$$Na_{(g)} \longrightarrow Na_{(g)}^{2+} + 2e^{-}$$
 $\Delta H = x$

(3)
$$Na_{(s)} \longrightarrow Na_{(g)}$$
 $\Delta H = y$

(4)
$$Na_{(s)} \longrightarrow Na_{(g)}^{2+} + 2e^{-}$$
 $\Delta H = z$

Which of the following equations represents the second ionization potential of sodium

- (a) Equation (2) × Equation (1).
- (b) Equation (2) Equation (1).
- © Equation (3) Equation (1).
- (d) Equation (4) Equation (3).

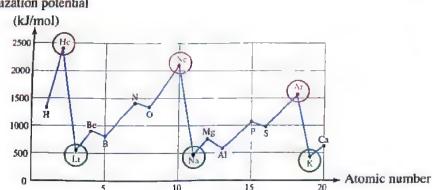
idea of answering:

- : The ionization potential indicates that the atom is in its gaseous state Na(g)
- .. The choices © and d are excluded.
- : Equation (2) represents both the first and the second ionization potentials, while equation (1) represents the first ionization potential only.
- .. The equation which represents the second ionization potential only is the difference of subtracting equation (1) from equation (2).

Answer: The correct choice is (b)

pplication 1 The first jouization potential of noble gases and alkali met ()

Ionization potential



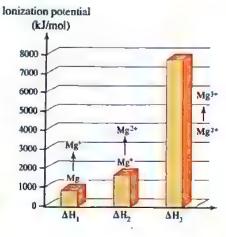


- The first ionization potential of noble gases is very high.. G.R.? Due to the stability of their electronic configuration and it is difficult to remove an electron from a completely filled shell.
 - * Examples: $_{10}$ Ne: [He], $2s^2$, $2p^6$
 - $_{18}\text{Ar}: [\text{Ne}], 3s^2, 3p^6$
- The first ionization energy of alkali metals is lower than that of all elements.. G.R.? Due to the ease of losing of the valence electron.
 - * Examples: $_{11}$ Na: [Ne], $3s^I$
- $_{19}$ K: [Ar], $4s^{1}$

The ionization potentials of magnesium :

The opposite figure expresses the ionization potentials of magnesium, it's clear that:

- The second ionization energy of magnesium is higher than the first one.. G.R.? Due to increasing the effective nuclear charge (Z_{eff}) .
- The third ionization potential of magnesium is much higher than its second ionization potential.. G.R.? Because it breaks a completely filled energy level.



$$Mg_{(g)}^{+} \longrightarrow Mg_{(g)}^{+} + e^{-}, \Delta H_{1} = +738 \text{ kJ/mol}$$

$$Is^{2}, 2s^{2}, 2p^{6}, 3s^{2} \qquad Is^{2}, 2s^{2}, 2p^{6}, 3s^{4}$$

$$Mg_{(g)}^{+} \longrightarrow Mg_{(g)}^{2+} + e^{-}, \Delta H_{2} = +1450 \text{ kJ/mol}$$

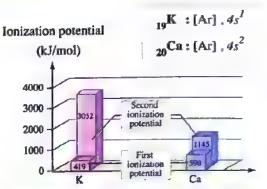
$$Is^{2}, 2s^{2}, 2p^{6}, 3s^{4} \qquad Is^{2}, 2s^{2}, 2p^{6}$$

$$Mg_{(g)}^{2+} \longrightarrow Mg_{(g)}^{3+} + e^{-}, \Delta H_{3} = +7730 \text{ kJ/mol}$$

$$Is^{2}, 2s^{2}, 2p^{6} \qquad Is^{2}, 2s^{2}, 2p^{5}$$

G.R. The first ionization potential of potassium 19K is lower than the first ionization potential of calcium 20 Ca, while the second ionization potential of 10K is much higher than that of 20Ca

The first ionization potential of potassium 10K is lower than that of calcium 20Ca, due to losing the valence electron easily, while the second ionization potential of potassium is much higher than that of calcium because it results in breaking a completely filled energy level.



Ionization potentials of potassium and calcium

Test Yourself

The opposite figure represents the second ionization potentials of some elements.

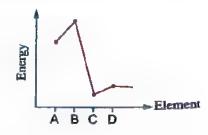
Which of them represents 3Li?

(a) A

(b) B

(c) C

(d) D



 \mathbf{E}_3

+4912 kJ/mol

Idea of answering:

The electronic configuration of 3Li is

- : The second ionization potential of lithium results in the breakage of a completely filled
- : Its second ionization potential is compared to those of the other elements.

Answer: The correct choice is

Worked Example

The opposite table shows the first three ionization potentials E1, E2 and E_3 of a metal.

What is the charge of the most stable ion of this metal?

(a)+1

- (b) +2
- ©+3

 \mathbf{E}_1

+590 kJ/mol

(d)+4

 \mathbf{E}_2

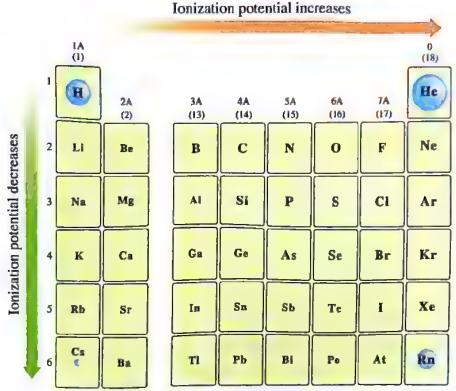
+1145 kJ/mol

Idea of answering:

- : The third ionization potential of this metal is much higher than its second ionization potential.
- : It results in breaking a completely filled (a stable) energy level.
- : The metal is divalent (belongs to group 2A).
- :. The charge of the most stable ion of this metal is +2

Answer: The correct choice is (b)

The graduation of ionization potential in the periodic table



Graduation of the ionization potential property in the elements of s and p blocks

In the same period

The first ionization potential increases as we move from left to right

In the same group

The first ionization energy decreases as we go down the group

This is due to

Charge and the decrease of the atomic radius, which would lead to increasing the attraction of the nucleus to the valence electrons, so they need higher energy to be separated from the nucleus

- The increase in the number of energy levels which are completely filled with electrons which increases the atomic radius.
- The decrease of attraction of the nucleus to the valence electrons,
 so the energy required to remove the valence electrons decreases.

i.e the ionization potential is inversely proportional to the atomic radius

G.R. (1) The ionization potential of phosphorus 15P is higher than the ionization potential of sulphur 16S, although phosphorus precedes sulphur in the same period.

Because the atom becomes more stable when the 3p sublevel is half filled with electrons as in phosphorus atom, and hence removing an electron from it will decrease its stability

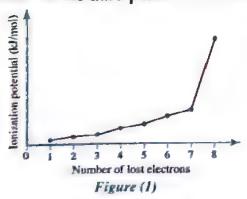
(2) The ionization potential of aluminum $_{13}\mathrm{Al}$ is lower than that of magnesium 12Mg, although aluminum comes after magnesium in the same period.

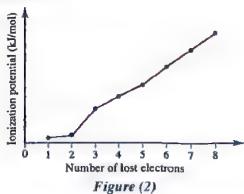
$$_{12}$$
Mg: [Ne], $3s^2$ $_{13}$ Al: [Ne], $3s^2$, $3p^I$

Because the atom becomes more stable when the 3s sublevel is completely filled with electrons as in magnesium atom, and hence removing an electron from it will decrease its stability.

Worked Example

The following graphical figures show the first eight ionization potentials of two elements in the third period in the modern periodic table :





What is the formula of the ionic compound which is produced from the combination of these two elements?

- (a) MgCl₂
- (c) Na₂S

- b) CaBr₂

Idea of answering:

- * In figure (1), there is a significant elevation in the 8th ionization potential of the compared to the lower ionization potentials, it means that removing 8 electrons from the atom of this element will lead to breaking a completely filled energy level.
 - .. The valence shell of this element contains 7 electrons, i.e. this element is located in group (7A) (the halogens), which means that it can be chlorine Cl or bromine Br
 - :. The choices © and d are excluded.
- * In figure (2), it is clear that the significant elevation appears in the 3rd ionization potential of this element.
 - .. The valence shell of this element contains 2 electrons, i.e. this element is located in group (2A), so it can be magnesium Mg or calcium Ca, but it is given in the data of the question that the element is located in the third period.
 - : Mg is in the third period, while Ca is in the fourth.
- : The choice b is excluded.

Answer: The correct choice is (a)

3 Electron affinity

We have mentioned that the removal of an electron from the atom will convert it into a cation, which requires an amount of energy named by the first ionization potential. On the other hand, if the atom gained an extra electron, it will be converted into a negative ion. This is associated with releasing an amount of energy named by electron affinity which is the amount of energy released when an extra electron is added to a neutral gaseous atom.

$$X_{(g)} + e^{-} \longrightarrow X_{(g)}^{-} + \text{Energy}$$
, $\Delta H = (-)$

• The magnitude of the electron affinity is high when the added electron makes the sublevel, half filled or completely filled, as in both cases it helps in the stability of the atom.

Test Yourself

Which of the following equations represents the electron affinity of chlorine?

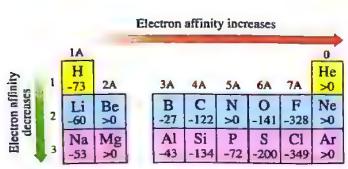
(b)
$$Cl_{(g)} + e^{-} \longrightarrow Cl_{(g)}^{-}$$

$$\odot Cl_{2(g)} + e^- \longrightarrow 2Cl_{(g)}^-$$

$$\textcircled{d} \operatorname{Cl}_{(g)}^+ + \operatorname{e}^- \longrightarrow \operatorname{Cl}_{(g)}$$

Answer: The correct choice is

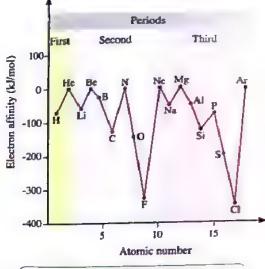
The graduation of electron affinity in the periodic table



The values of the electron affinities of the first 18 elements in the periodic table "in kJ/mol"

In the same period

The electron affinity increases as we move from left to right



In the same group

The electron affinity decreases as we go down the group

This is due to

The increase of the atomic number leads to the decrease in the atomic radius (and hence the atomic size), which facilitates for the nucleus to attract a new electron

The increase of the atomic number leads to the increase in the atomic radius (and hence the atomic size), which hinders the nucleus to attract a new electron

G.R. (1) The electron affinity values for beryllium $_4$ Be, nitrogen $_7$ N and neon $_{10}$ Ne are close to zero.

 $_{4}$ Be: $1s^{2}$, $2s^{2}$, $_{7}N: 1s^{2}, 2s^{2}, 2p^{3}$, $_{10}Ne: 1s^{2}, 2s^{2}, 2p^{6}$

Because the atom will be more stable when the sublevel;

- 2s is completely filled as in case of beryllium atom ABe
- 2p is half filled as in case of nitrogen atom 7N
- 2p is completely filled as in case of neon atom 10Ne and the addition of an electron to any atom of them will decrease its stability.
 - (2) The electron affinity of chlorine (- 349 kJ/mol) is greater than the electron affinity of fluorine (- 328 kJ/mol), although chlorine follows fluorine in the same group.

Because fluorine atom is smaller in size as it has smaller radius than chlorine atom, so any new electron will suffer a strong repulsive force with the nine electrons already existing around the fluorine nucleus which decreases the released energy due to consuming a part of this energy to overcome this repulsive force.

Worked Example

Based on the equation and the table :

$$K_{(g)} + Cl_{(g)} \longrightarrow K_{(g)}^+ + Cl_{(g)}^- \quad \Delta H = ?$$

What is the value of ΔH ?

- (a) 1303 kJ/mol
- (b) 1207 kJ/mol
- © 767 kJ/mol
- (d) 69 kJ/mol

	potentia!	et into
Potassium	+418 M.mol	-48 kJ/mol
Chlorine	+1255 kJ/mol 1	-349 kJ/mol

Idea of answering:

•
$$K_{(g)} \longrightarrow K_{(g)}^+ + e^-$$

• $Cl_{-} + e^- \longrightarrow Cl_{-}^-$

$$\Delta H = +418 \text{ kJ/mol}$$

$$\bullet$$
 $Cl_{(g)} + e^- \longrightarrow Cl_{(g)}^-$

$$\Delta H = -349 \text{ kJ/mol}$$

By addition

$$K_{(g)} + Cl_{(g)} \longrightarrow K_{(g)}^+ + Cl_{(g)}^-$$

$$\Delta H = (+418) + (-349) = 69 \text{ kJ/mol}$$

Answer: The correct choice is (d)

Electronegativity

- When two atoms of two different elements combine together, the ability of one atom of them to attract the electrons of the chemical bond differs from that of the other atom, this attraction force is known as
- electronegativity which is the ability of an atom to attract the electrons of the chemical bond to itself.
- The electron affinity differs from the electronegativity, where the electron affinity is an energy term which refers to an atom in its single state, while the electronegativity of the elements is represented by relative values and it refers to a combined atom.
 - * The increase of the relative values of the electronegativity means the increase in the ability of the element atom to attract the electrons of the chemical bond.



* The difference in electronegativity between elements plays a very important role in determining the nature of the bond formed between them (as will be discussed later in chapter 3 - second term).

The graduation of electronegativity in the periodic table

		Electronegativity increases									
					~			<u> </u>		_	<u> </u>
			1A								
		. [Н								
		l l	2.1	2A			3A	4A	5A	6A	7A
Ses			Li	Be			В	С	N	0	F
2		2	1.0	1.5			2.0	2.5	3.0	3.5	4.0
dec			Na	Mg			Al	Si	P	S	Cl
/ity	4	3	0.9	1.2			1.5	1.8	2.1	2.5	3.0
ativ			K	Ca			Ga	Ge	As	Se	Br
geu		4	0.8	1.0			1.6	1.8	2.0	2.4	2.8
Electronegativity decreases			Rb	Sr	7		In	Sn	Sb	Te	I
<u>표</u>		5	0.8	1.0			1.7	1.8	1.9	2.1	2.5
		6	Cs	Ba	1	5	Tl	Pb	Bi	Po	At
4		0	0.7	0.9	((1.8	1.9	1.9	2.0	2.2

In the same period

The electronegativity increases as we move from left to right

In the same group

The electronegativity decreases as we go down the group

This is due to

The increase of the atomic number leading to the decrease of atomic radius, so the ability of the atom to attract the electrons of the bond increases

The increase of the atomic number leading to the increase of atomic radius, so the ability of the atom to attract the electrons of the bond decreases

General conclusion:

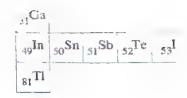
- The atoms of nonmetals of group 7A (halogens) are the greatest in the electronegativity, while the atoms of the alkali metals of group 1A are the lowest in the electronegativity.
- Fluorine (F) is the most electronegative element, while cesium (Cs) is the lowest electronegative element.

Worked Example

The opposite figure shows a section in the modern periodic table.

Determine with explanation :

- (1) The element which has the lowest electronegativity.
- (2) The element which has the highest electronegativity.



Answer:

- (1) : The electronegativity decreases in the same group by increasing the atomic number.
 - .. The electronegativity of Tl element is the lowest.
- (2) : The electronegativity increases in the same period by increasing the atomic number.
 - .. The electronegativity of I element is the highest.

Multiple choice questions





The atomic radius

1	If the length of the bond in A_2 molecule equals 1.98 Å, and the length of the bond in
	AB molecule equals 1.29 Å

What is the bond length in B2 molecule?

- ⓐ 0.69 Å
- (b) 3.27 Å
- (c) 1.32 Å
- (d) 0.6 Å
- The element with the smallest atomic radius among the elements of the same group is that which has
 - (a) the highest number of neutrons inside the nucleus.
 - (b) the lowest number of protons inside the nucleus.
 - (c) the lowest electronegativity.
 - d the highest number of electrons around the nucleus.
- The biggest atoms in size in the periodic table are those of
 - (a) alkali metals.
- (b) group 1B
- © group 8
- (d) halogens.
- - (a) 3Li

- (b) oF

The opposite table exhibits the electron configuration of an atom in its ground state and that of its ion.

Electronic configuration of the atom	$1s^2$, $2s^2$, $2p^6$, $3s^2$, $3p^3$
Electronic configuration of the ion	$1s^2$, $2s^2$, $2p^6$, $3s^2$, $3p^6$

Which of the following conversions represents this atom?

(a) B → B³⁺

(b) Al ----- Al³⁺

(c) $N \longrightarrow N^{3-}$

(d) P ----- P³-

6 Oxygen ion $^{16}_{8}O^{2-}$	contains					
(a) 8 protons, 10 e	lectrons.	(b) 10 protons,	8 electrons.			
© 8 protons, 9 ele	ectrons.	d 10 protons,	7 electrons.			
The highest number	per of the unpaired ele	ectrons is in	[Atomic pumper / / /			
a) Fe	ⓑ Fe⁴+	© Fe ²⁺	(d) Fe ³⁺			
The effective nucl	lear charge is the high	nest in				
(1) 22Ti	 ₂₆ Fе	© ₂₂ Ti ³⁺	(d) 26Fe ³⁺			
The atomic radius	of fluorine ₉ F is sma	ller than that of car	bon ₆ C, because			
a the quantum nu	umbers of the last elect	ron of F atom are sm	aller than those of C atom			
b the repulsion b	etween the electrons of	f the completely fille	d p orbitals is stronger tha	n		
that between th	e electrons of the half	filled p orbitals.				
© the effective nu	iclear charge of fluorin	e is larger than that o	of carbon.			
d fluorine is heav	vier than carbon.					
Tarkish of the following		ant for the decision	(a)			
1	owing relations is corn		of the same period ?			
	(a) The radius of M^+ ion > That of X^- ion.					
(b) The radius of X ion > That of X atom.						
© The radius of M^+ ion = That of X^- ion.						
d The radius of M	M^+ ion > That of M atom	n.				
Which of the follo	wing ions has the larg	gest radius ?				
a F	⊕ Li ⁺	©Г	d Rb ⁺			
 	us of rubidium is 2.53	Å				
What would its io		1-				
(a) 1.48 Å	(b) 2.53 Å	© 2.75 Å	(d) 3 Å			
(a) 1,46 A	(I) 2.55 A	C) 2.13 K	(0) 5 A			
The ratio between	n the atomic size of th	e cation and that of	the anion is the greatest			
in						
(a) CsI	(b) CsF	© NaF	(d) KF			
Which of the follo	wing is the correct gr	aduation of the ion	ic radii of these ions?			
(a) $_{12}Mg^{2+} < _{9}F^{-} <$	8O2-	(b) $_{9}F^{-} < _{12}Mg^{2}$	+ < gO ²			
$\bigcirc_{9}F^{-}<_{8}O^{2-}<_{12}$	Mg ²⁺	(d) $_{12}Mg^{2+} < _{R}C$) ²⁻ < ₀ F ⁻			
- 7 6 12		- 12 - 0	_	49		

- The element whose electronic configuration ends with ns2
 - (a) its ion has smaller radius than that of its atom.
 - (b) its ion has larger radius than that of its atom.
 - (c) its atom has smaller radius than that of its positive ion.
 - (d) its atom has smaller radius than that of the atom of the element which precedes it in the same group.

Ionization potential

Mhich of the following equations represents the second ionization potential of element M?

(a)
$$M_{(g)}$$
 + Energy \longrightarrow $M_{(g)}^+$ + e^- (b) $M_{(g)}^+$ + Energy \longrightarrow $M_{(g)}^{2+}$ + e^-

ⓑ
$$M_{(g)}^+$$
 + Energy — $M_{(g)}^{2+}$ + e^-

$$\bigcirc$$
 $M_{(g)}^- + e^- \longrightarrow M_{(g)}^{2-} + Energy$ \bigcirc $M_{(g)}^+ + e^- \longrightarrow M_{(g)} + Energy$

$$\bigcirc$$
 $M_{(g)}^+ + e^- \longrightarrow M_{(g)} + Energy$

Which of the following elements has the lowest second ionization potential?

This table shows the first three ionization potentials of magnesium element. What is the amount of energy required to obtain magnesium ion which has the same electron configuration of the nearest noble gas?

First ionization potential	+738 kJ/mol
Second ionization potential	+1451 kJ/mol
Third ionization potential	+7733 kJ/mol

(a) +1451 kJ/mol

(b) +2189 kJ/mol

(c) +9184 kJ/mol

(d) +9922 kJ/mol

- In the opposite table : How can the change in the second ionization potential be explained?
 - (d) The first and second ionization potentials are from two different energy levels in sodium,

Element	Na	Mg
First ionization potential (kJ/mol)	+496	+738
Second ionization potential (kJ/mol)	+4558	+1451

while in magnesium they are from the same energy level.

- (b) Electronegativity of sodium is lower than that of magnesium.
- (c) Losing an electron from magnesium atom causes the other electron to repel with magnesium cation.
- d Losing an electron from sodium atom causes the half filling of 2p sublevel, while it requires losing two electrons from magnesium atom to cause 2p sublevel to be half filled.

	▶ Lesson T _A
20 The second ionization potential is n	nuch higher than the first ionization potential of
the atom of	
a neon 10 Ne	ⓑ potassium 19K
© magnesium ₁₂ Mg	(d) aluminum ₁₃ Al
If the ionization potential of hydrog	gen $ m H_{(g)}$ equals +1312 kJ/mol, it is most likely that
the second ionization potential of h	elium $\mathrm{He}_{(\mathrm{g})}$ equals
(a) +5248 kJ/mol	(b) +1312 kJ/mol
© +656 kJ/mol	(d) +328 kJ/mol
Which of the following equations is	incorrect?
ⓐ Na + e ⁻ → Na ⁺ + Energy	ⓑ Mg + Energy \longrightarrow Mg ²⁺ + 2e ⁻



located in group (2A) in the modern periodic table are represented as follows:

(1) $X_{(n)} \longrightarrow X_{(n)}^+ + e^-$, $\Delta H = +589.8 \text{ kJ/mol}$

(1)
$$X_{(g)} \longrightarrow X_{(g)}^+ + e^-$$
, $\Delta H =$

(2)
$$X_{(g)}^{+} \longrightarrow X_{(g)}^{++} + e^{-}$$
 , $\Delta H = +1145.4 \text{ kJ/mol}$

What is the probable value of the third ionization potential of (X)?

24 Which of the following has a higher value in lithium Li than in potassium K?

Electron affinity

Which of the following represents the proper graduation in the electron affinity?

26 Bromine forms a negative ion, while po	tassium forms a po	sitive ion, because			
a potassium has higher ionization poten	tial than bromine.				
(b) the atomic size of bromine is larger than that of potassium.					
© the electron affinity of bromine is larg	er than that of potas	sium.			
d) potassium has higher electronegativity	y than bromine.				
Which of the following represents the p	proper graduation ?				
(a) Electron affinity $\binom{17}{6}$ Cl $\binom{8}{9}$ Cl $\binom{9}{9}$ F).	(b) Ionization pot	ential $(_{19}K < _{12}Mg < _{13}Al)$.			
© Atomic radius $(_{33}As < _{15}P < _{14}Si)$.	d Ionic radius ($_{2}$ Mg ²⁺ < $_{20}$ Ca ²⁺ < $_{19}$ K ⁺).			
Electronegativity					
28 Which of the following elements has th	e highest electrone	egativity compared to			
the other elements in the periodic table	e ?				
(a) ₂ He (b) ₉ F	© 11 Na	(d) ₁₃ A1			
Increasing the distance between the la	st electron and the	nucleus in an atom			
leads to ·····					
a increasing the electron affinity.					
b the ease of losing this electron.					
© increasing the attraction between the	electron and the nuc	eleus.			
d increasing the electronegativity.					
30 Halogens are characterized by all the f	ollowing, except				
a high electronegativity.	b small atom	ic radius.			
© high ionization energy.	d small elect	ron affinity.			
31 What is the property which decreases	in the same period	with increasing			
the atomic number ?					
(a) Ionization potential.	(b) Electron at	ffinity.			
© Electronegativity.	d Atomic rad	lius.			
32 In the third period, on moving from so	dium to chlorine, b	oth			
a the atomic number and the atomic size	ze increase.				
(b) the atomic number and the electrone	gativity increase.				
© the electronegativity and the atomic	size increase.				
d the atomic size and the ionization po	tential increase.				
152					

- In the same period, the element which gains electrons during the chemical reactions is characterized by
 - (a) lower electron affinity.
 - (b) higher electronegativity.
 - © lower first ionization potential.
 - (d) larger atomic radius.
- 34 Which of the following choices represents the proper graduation in electronegativity?

(a)
$$_{6}C < _{7}N < _{14}Si < _{15}P$$

©
$$_{7}N < _{6}C < _{15}P < _{14}Si$$

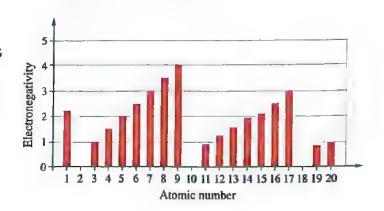
(b)
$$_{14}Si < _{15}P < _{6}C < _{7}N$$

(d)
$$_{6}C < _{14}Si < _{7}N < _{15}P$$

In the opposite graph:

Which of the following elements is characterized by the highest ability to attract the electrons?

- (a) ₅B
- (b) ₈O
- © 13Al
- (d) 16S



The following table shows the values of the atomic radii of four elements located in the same group in the periodic table (estimated in angstroms):

Element	A	В	C	D
Atomic radius (Å)	1.9	2.43	1.67	2.65

Which of the following choices is correct?

- (a) The electronegativity of (A) is lower than that of (B).
- (b) The electronegativity of (D) is higher than that of (C).
- © The electron affinity of (C) is lower than that of (A).
- ① The ionization potential of (B) is higher than that of (D).

The Periodic Table and Classification of Elements



- Give reason:
- (I) The atomic radius can not be estimated (or measured physically) by the distance
- between the nucleus and the farthest electron. (2) The ionization potential of phosphorus $_{15}P$ is higher than that of sulphur $_{16}S$,
- although phosphorus precedes sulphur in the same period.
- (3) It is very difficult to obtain the ion \mathbb{M}^{2+} from element \mathbb{M} which lies in
- Al quong, borned bug
- (4) The electron affinity of each of neon, beryllium and nitrogen is almost zero.
- (5) The electron affinity of fluorine is lower than that of chlorine, although
- the atomic size of fluorine is smaller.
- 38 If you know that:
- Å 00.0 = 0.0 ength in water molecule = 0.00 Å
- A $\Delta \mathcal{E}_{L} = (\Omega)$ elucion mogya ni ni dignel brod enfr
- Calculate the covalent radius of hydrogen atom.
- 15 It you know that :
- A 99.0 = aninola of chlorine = 0.99
- The bond length in ammonia molecule = 1 A
- The bond length in hydrogen chloride molecule = 1.29 Å
- Calculate which is longer, the bond in hydrogen molecule or the bond in nitrogen molecule.

: oldes gniwollos of the following table :

28.1	1.14	86.0	98.1	£.0	75.1	(Å) suibeA
Br	Br	+ _E N	BN	H	_H	noi 10 motA

Calculate - with giving reason - the bond length in each of :

- (1) The formula unit of sodium bromide.
- (2) Hydrogen bromide molecule.
- Arrange the following elements descendingly, with giving the reason:
- ."According to the radius". P_{02} , P_{03} , P_{04} , P_{04} , P_{04}
- (2) I_2 , Br_2 , F_2 , Cl_2 "According to the bond length in the molecule".



- Choose the number(s) of the statement(s) which illustrate(s) the difference between phosphide ion and phosphorus atom 15P:
 - (1) The atomic radius of phosphorus is larger than the ionic radius of phosphide.
 - (2) Phosphide ion contains higher number of electrons than in phosphorus.
 - (3) Numbers of energy levels which are occupied by electrons in both of them are equal.
- The opposite table shows the atomic and the ionic radii of sulphur and calcium:

(1) Why is sulphide ionic radius larger that	an
the atomic radius of sulphur?	

(2) Why is the radius of S^{2}	larger than that of Ca2+
despite the similarity in	their electronic configuration?

Element	Radius (nm)
₁₆ S	0.104
S ²	0.184
₂₀ Ca	0.197
Ca ²⁺	0.099

- Write the electronic configuration (according to Aufbau principle) of the element which is located in the third period in the modern periodic table, and the difference between its fifth and sixth ionization potentials is very large.
- 15 In the equation :

$$M_{(g)}^+$$
 + Energy \longrightarrow $M_{(g)}^{++}$ + e^-

- (1) What does the energy represent in the previous equation?
- (2) Which is larger in radius, M+ or M++? Why?
- Write the symbolic equation which represents the third ionization potential of titanium (Ti).
- 57 In the light of your studying for :
 - Radius.

• Ionization potential.

Electron affinity.

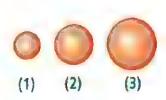
Electronegativity.

What are the values required to calculate the change in energy of the reaction:

$$Na_{(g)} + Cl_{(g)} \longrightarrow Na_{(g)}^+ + Cl_{(g)}^-$$

of each of ₃₅Br , Br⁻ and ₉F "in no particular order".

Choose, with explaining your answer, the proper figure number for each atom or ion.



155

1 The following figure represents the first four periods in the periodic table



"The letters in the table are not the real symbols of the elements"

Choose the symbol(s) of the element which:

- (1) Has the largest radius in the third period.
- (2) Has the lowest ionization potential in group 2A
- (3) Has the highest electronegativity.
- (4) Forms compounds with great difficulty.
- (5) Has the highest first ionization potential.
- (6) Has an electron affinity higher than (G).

Higher – order questio	ins (b)
	Answered in detail

Choose the correct answer :

- - (a) 0.85
- **(b)** 0.88
- ©1
- d 1.33
- Metal M forms the oxides (MO, M2O3, MO2).

What is the correct order of these oxides according to the bond length?

 $MO < M_2O_3 < MO_2$

(b) $M_2O_3 < MO < MO_2$

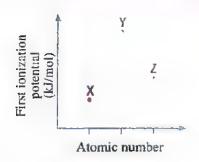
 $\bigcirc MO_2 < M_2O_3 < MO$

- (d) $MO_2 < MO < M_2O_3$
- If the four quantum numbers of the last electron in the valence shell of the atom of the element (X) are: $(4,3,0,+\frac{1}{2})$ respectively.

What is the atomic number of the element (Y) which has the biggest atomic size in the same period of the element (X) ?

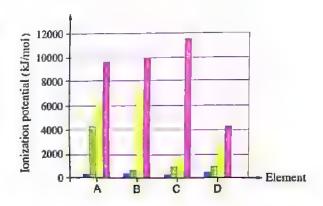
(a) 19

- **b** 37
- © 55
- d 71



- (a) carbon ₆C
- b fluorine pF
- © oxygen 80
- d nitrogen 7N
- The opposite graphical figure represents the first four ionization potentials of 4 elements (A), (B), (C) and (D).

 What is the letter of the element which represents aluminum?



(a) (A).

(b) (B).

© (C).

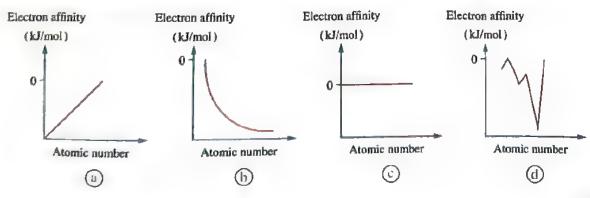
- (d) (D).
- The following table represents the first five ionization potentials of the element (X) in kJ/mol:

lonization potential	First	Second	Third	Fourth	Fifth
Value of ionization potential (k,J/mol)	+738	+1450	+7733	+10543	+13630

What is the chemical formula of the compound which is produced from the combination of the element (X) with chlorine?

(a) XCI

- ⓑ XCl₂
- © XCl₃
- d X_2Cl_3
- Which of the following charts represents the relation between the electron affinity and the atomic number in the elements of the third period in the periodic table ?



In the equation : $X_{(g)}$ + Energy $\longrightarrow X_{(g)}^+ + e^-$ The absorbed energy is

(a) less than the difference in energy between the outermost energy level and . evel Q

(b) equal to the difference in energy between the outermost energy level and the level Q

© larger than the difference in energy between the outermost energy level and evel Q

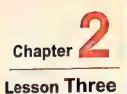
d half the difference in energy between the outermost energy level and the i. Q

Essay question:

In the two compounds of chromium CrO, Cr2O3:

- (1) What is the number of electrons in chromium ion in each of the two compounds?

 "Knowing that the atomic number of chromium is 24".
- (2) In which formula unit the (Cr O) bond length is longer, CrO or Cr₂O₃? Give reason.



From Meierille करते तांकाताहास्त्रीति क्रिकेट करा

Until Before the caldation number



Metallic and nonmetallic property

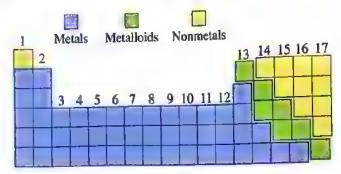
 At the beginning of the nineteenth century, "Berzelius" was the first scientist who classified elements into two main groups (metals and nonmetals), according to their physical properties. Indeed that was before knowing anything about atomic structure.



 This is an old classification which is still currently in use, although there are no boundaries between their properties.



- With the development of our concept of the electronic structure of atoms, we can differentiate between metals and nonmetals. In addition to, a third group of elements known as metalloids.
- Metals.
- Nonmetals.
- Metalloids.



Classification of the modern periodic table elements into metals, nonmetals and metalloids



Metals

- Their valence shell generally has

 less than half its capacity of electrons.
- 2 They have large atomic radius which leads to small values for ionization energy and electron affinity.
- They are electropositive elements,... G.R.?

 Due to their tendency to lose electrons of the valence shell and change into positive ions to reach the structure of the nearest noble gas.
- O They are good electric conductors,.. G.R.?

 Due to the mobility of their few

 valence electrons, which can transfer

 from one position to another in the

 metal structure.



Nonmetals

- Their valence shell generally has more than half its capacity of electrons.
- They have small atomic radius which leads to high values for ionization energy and electron affinity.
- They are electrones, two elements,... G.R.?

 Due to their tendency to geth electrons to form negative ions that have the same electron structure of the nearest noble gas.
- They don't conduct electricity

 (electric insulators),.. G.R.?

 Because their valence electrons are

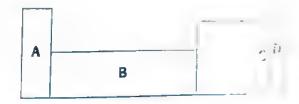
 strongly bound to the nucleus. Thus it is

 difficult for these valence electrons to be

 transferred.

Worked Example

The opposite figure represents a section in the periodic table. In which of the illustrated zones can a diatomic molecule element which does not conduct electricity be found?



(a) A

(b) B

© C

(d) D

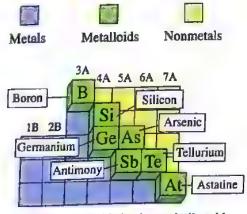
Idea of answering:-

- : Nonmetals and noble gases do not conduct electricity, and they lie on the right side of the periodic table.
- .. The choices (a) and (b) are excluded.
- : Zone (D) in the periodic table contains the noble gases, and these are monatomic elements.
- :. The choice (d) is excluded.

Answer: The correct choice is ©

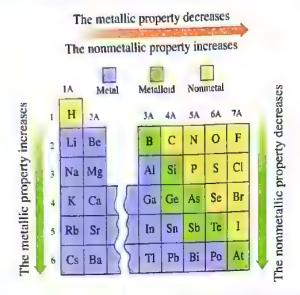
Metalloids

- The metalloids are characterized by the following properties:
 - They have the metallic appearance and most of the properties of the nonmetals.
- 1 Their electronegativity is intermediate between metals and nonmetals.
- Their electric conductivity is less than that of metals, but more than that of nonmetals.
- O They are used in manufacturing some electronic instruments parts, such as transistors, as they are semiconductors.



The metalloids in the periodic table

The graduation of metallic and nonmetallic property in the periodic table



The graduation of the metallic and nonmetallic properties in the periodic to

In the same group

The metallic property increases

(the nonmetallic property decreases)
with the increase in the atomic number
as we go down the group... G.R.?

Due to their large atomic radius
and the low ionization potential and
electron affinity

In the same period

in group IA, then the metallic property
decreases gradually by increasing
the atomic number along the period
till we reach the metalloids
To the right of the metalloids
the nonmetallic property begins to appear
The period ends with the elements of
the highest nonmetallic property in group 7A

G.R. (1) Cesium Cs is considered the most active metal (loses its valence electron easily).

Because the metallic property increases in the same group by increasing the atomic number and it is located at the bottom of the left hand side of the table (the metal with the lowest ionization potential).

(2) Fluorine F is considered the most active nonmetal (gains a new electron easily).

Because the nonmetallic property increases in the same period by increasing the atomic number and it is located at the top of the right side of the table (the most electronegative nonmetal).

pplication The graduation of metallic and nonmetallic property:

- The following figure expresses the graduation of metallic and nonmetallic property: in the third period.
- It is clear that by increasing the atomic number, the metallic character decreases and the nonmetallic character increases.

Third period							
	Na \	Vaguesium 2Mg		Silicon F	hosphorus	Sulphur (Chlorine
Electron configuration	3s1	3s ²	3s ² ,3p ¹	$3s^2,3p^2$	$3s^2,3p^3$	$3s^2,3p^4$	$3s^2,3p^5$
Element	Strong metal	Metal	Metal	Metalloid	Nonmetal	Nonmetal	Strong nonmetal

As the atomic number increases, the metallic property decreases and the nonmetallic property increases

Test Yourself

- Which of the following represents the electronic configuration of the most electropositive element?
 - (a) [He], $2s^{1}$

(b) [Ne], $3s^2$

(c) [Xe], 6s1

(d) [Xe], $6s^2$

Answer: The correct choice is

1 The table shows the ionization potentials of three metals A, B and C located in the same period in the modern periodic table.

Element	Α	В	C
lonization potential (k,J/mol)	550	600	700

What is the proper graduation of the metallic character of these elements?

(a) B < C < A

(b) A < C < B

(c) C < B < A

(d) A < B < C

Answer: The correct choice is

6 Acidicand basic property

- When an element combines with oxygen, they form a compound known as oxide.
- There are three types of elements oxides, which are:
 - A Acidic oxides.
- B Basic oxides.
- C Amphoteric oxides.

Acidic oxides

• The nonmetals oxides are usually known as acidic oxides, .. G.R.?

Because:

They dissolve in water forming oxygenated acids.

$$CO_{2(g)}$$
 + $H_2O_{(l)}$ \longrightarrow $H_2CO_{3(aq)}$
Carbon dioxide Water Carbonic acid
 $SO_{3(g)}$ + $H_2O_{(l)}$ \longrightarrow $H_2SO_{4(aq)}$
Sulphur trioxide Water Sulphuric acid

Among the acidic oxides

- Carbon dioxide CO₂
- Sulphur trioxide SO₃
- Nitrogen dioxide NO₂
- 1 They react with alkalis forming salt and water.

🔪 Test Yourself

Write the balanced symbolic equation which represents the reaction of sulphur trioxide with sodium hydroxide.

B Basic oxides

- The metals oxides are usually known as basic oxides.
- Some basic oxides are not soluble in water and others are soluble in water forming alkalis, the water soluble basic oxides are also known as alkali oxides.

$$Na_2O_{(s)}$$
 + $H_2O_{(l)}$ \longrightarrow $2NaOH_{(aq)}$
Sodium oxide Water Sodium hydroxide $K_2O_{(s)}$ + $H_2O_{(l)}$ \longrightarrow $2KOH_{(aq)}$
Potassium oxide Water Potassium hydroxide

Among the basic oxides

- Sodium oxide Na₂O
- Potassium oxide K₂O
- Magnesium oxide MgO

• They react with acids forming salt and water:

$$Na_2O_{(s)}$$
 + $2HCl_{(aq)}$ \longrightarrow $2NaCl_{(aq)}$ + $H_2O_{(l)}$
Sodium oxide Hydrochloric acid Sodium chloride Water

 $MgO_{(s)}$ + $H_2SO_{4(aq)}$ \longrightarrow $MgSO_{4(aq)}$ + $H_2O_{(l)}$

Magnesium oxide Sulphuric acid Magnesium sulphate Water

Write the balanced symbolic equation which indicates:

- (1) The dissolution of calcium oxide in water.
- (2) The reaction of calcium oxide with phosphoric acid.

Amphoteric oxides

Amphoteric oxides are elements oxides that react with acids as basic oxides and react with alkalis as acidic oxides forming in both cases salt and water.

- Aluminum oxide Al₂O₃
- Zinc oxide ZnO
- Antimony oxide Sb₂O₃
- Tin (II) oxide SnO

$$ZnO_{(s)}$$
 + $H_2SO_{4(aq)}$ \longrightarrow $ZnSO_{4(aq)}$ + $H_2O_{(l)}$
 $Zinc$ oxide Sulphuric acid Zinc sulphate Water

 $ZnO_{(s)}$ + $2NaOH_{(aq)}$ \longrightarrow $Na_2ZnO_{2(aq)}$ + $H_2O_{(l)}$
 $Zinc$ oxide Sodium hydroxide Sodium zincate Water

View Yourself

Write the balanced symbolic equation which indicates:

- 1) The reaction of tin (II) oxide with nitric acid.
- ? The reaction of tin (II) oxide with sodium hydroxide.

The graduation of acidic and basic property in the periodic table

In the period	In the group				
. basic property of	In the group which starts with a metal	In the group which starts with a nonmetal			
the oxide decreases as the atomic number of the element increases, while the acidic property increases	The basic property of the oxide increases as the atomic number of the element increases, as in group 1A	The acidic property of the hydrogen compounds increases as the atomic number of the element increases, as in group 7A			

A polication

The graduation of acidic and basic property in the third period.

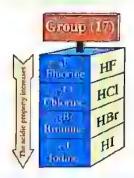
• The following figure expresses the graduation of acidic and basic property in the unitd period. It is shown that, as the atomic number increases the basic property decreases and the acidic property increases.

Third period	Sodium	Magnesimm 12Mg	1	Alamana Alama		(Chlorine
Domeot oxide	Na ₂ O	MgO		Al ₂ O ₃	SiO ₂	P ₂ O ₅	so,	Cl ₂ O ₇
Oxide	Basic oxide			Amphateric oxide	Acidic oxide			
The	NaOH	Mg(OH),	١	A1(OH)3	H ₄ SiO ₄	H ₃ PO ₄	H ₂ SO ₄	нсю
neithe neithe and busic	Strong base	Weak base	I	Amphoteric substance	17.500	Moderate acid	Strong acid	The stronger actd
								_

As the atomic number increases, the basic property decreases and the acidic property increases

G.R. The acidic property of hydrogen compounds of group 17 (the halogens) increases as the atomic number increases.

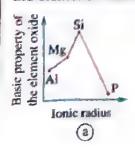
Because the increase in the atomic number in the group elements leads to the increase in the atomic radius of the halogen, therefore its attraction force to hydrogen atom decreases, making it easier to be ionized.

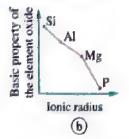


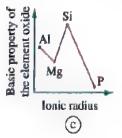
The graduation of acidic property of halogens

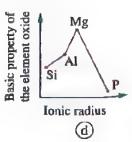
Worked Example

Which of the following graphs represents the relation between the basic property of the element oxide and its ionic radius?









idea of answering: ---

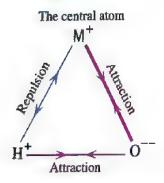
- The basic property of the elements oxides decreases by increasing their atomic numbers in the same period.
- : The basic property of aluminum oxide is less than that of magnesium oxide.
- .. The choices (b) and (c) are excluded.
- . The basic property of silicon oxide is less than that of aluminum oxide.
- . The choice (a) is excluded.

Answer: The correct choice is (d)

The acidic and basic property of the hydroxy compounds

- The oxygenated acids (acids contain oxygen) and bases are considered as hydroxy compounds, they can be represented by the general formula (MOH), where M represents the element atom.
- The hydroxy compounds can be ionized by either ways:

As an acid



The compound will be ionized as an acid if:

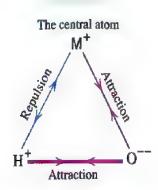
The (M - O) bond is stronger than

is (O - H) bond.

The attraction between M+ and O-

a stronger than that between H+ and O--).

As a base



The compound will be ionized as a base if:
The (O – H) bond is stronger than
the (M – O) bond.

(i.e. The attraction between H⁺ and O⁻⁻ is stronger than that between M⁺ and O⁻⁻).

MOH — M+ OH
Base Negative

hydroxide ion

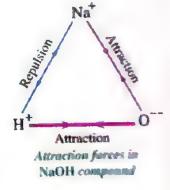
Note

If the strength of (M-O) bond and the strength of (O-H) bond are e_{O} , the substance will be ionized as an acid or a base depending on the reaction medium, this means that it reacts as a base in the acidic medium and as an acid in the basic medium.

- In general, the attraction between each of (O^{--}, M^+) and (O^{--}, H^+) depends on :
 - The volume of M atom.
 - The charge of M in the compound.

Application 1 The basic property of sodium hydroxide.

Sodium hydroxide is ionized as a base, where sodium atom has a large volume and its ion has only one positive charge. Accordingly, the attraction between Na⁺ and O⁻⁻ decreases
 i.e. The (O - H) bond is stronger than that of the (Na - O) bond.



So OH⁻ ion is produced.

Application (2) The acidic property of HClO,

Across the same period, the size of the nonmetal atoms as chlorine decreases, and
the electronegativity increases, so its attraction to O⁻⁻ increases,
hence HClO₄ is ionized as an acid:

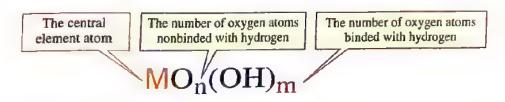
$$HClO_4 \longrightarrow H^+ + ClO_4^-$$

G.R. Hydroxy compounds of the nonmetals as bromine are ionized as acids.

Because the nonmetals have small atomic size and high electronegativity, so the attraction to O^{-} increases and the bond (Br - O) becomes stronger than the (O - H) bond, so the positive hydrogen ion is produced.

The strength of the oxygenated acids (oxyacids)

• The oxygenated acids are represented by the following general formula:



ullet The strength of the oxygenated acid (oxyacid) increases as the number of nonbinded oxygen atoms (O_n) with hydrogen increases as shown in the following table :

Acid anion	Silicate group SiO ₄ ⁴	Phosphate group PO ₄ ³⁻	Sulphate group SO_4^{2-}	Perchlorate group ClO ₄
Oxygenated acid (oxyacid)	Orthosilicic acid H ₄ SiO ₄	Orthophosphoric acid H ₃ PO ₄	Sulphuric acid H ₂ SO ₄	Perchloric acid HClO ₄
Hydroxy formula MO _n (OH) _m	HO, OH	O HOOH HOOH	O OH	O O O
Ratio n : m	0:4	1:3	2:2	3:1
No. of nonbinded oxygen atoms with hydrogen	zero		2	Ž
Strength of the acid	Weak	Moderate	Strong	The strongest

Worked Example

Among the oxygenated acids are:

Which of the following is correct for these acids?

- (a) HBrO is the weakest acid among these three acids.
- (b) HBrO₃ acid contains 3 oxygen atoms nonbinded to hydrogen atoms.
- © HBrO2 is the strongest acid among these three acids.
- d The ratio (n: m) in HBrO equals (1:1).

Idea of answering:

The following table exhibits the hydroxy formulas of these oxygenated acids,

and (n: m) ratio in each of them:

Oxygenated acid	HBrO	HBrO ₂	HBrO ₃		
Hydroxy formula	Br(OH)	BrO(OH)	BrO ₂ (OH)		
n:m	0:1	1:1	2:1		

- The strength of the oxygenated acid increases by increasing the number of nonbinded oxygen atoms with hydrogen.
- .. These acids are ordered ascendingly according to the strength as follows:

$${\rm HBrO} < {\rm HBrO}_2 < {\rm HBrO}_3$$

Answer: The correct choice is (a)

By increasing the atomic number

The following increases:

- The atomic radius.
- The metallic property.
- The acidic property of the nonmetals of group 7A
- The basic property of metals.

The following decreases:

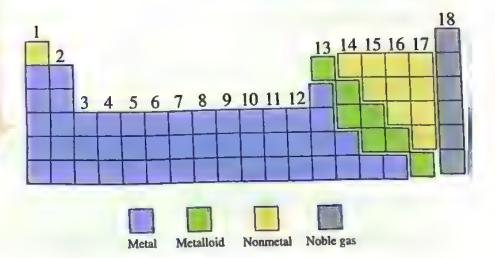
- The ionization potential.
- The electron affinity.
- The electronegativity.
- The nonmetallic property.

The following increases:

- The ionization potential.
- The electron affinity.
- The electronegativity.
- The nonmetallic property.
- The acidic property.

The following decreases:

- The atomic radius.
- The metallic property.
- The basic property.



Graduation of properties of the elements in the periodic table

Multiple aboice questions





	Metallic and nonmetallic property	
	The nonmetals are characterized by	
	a high ionization energy.	
	(b) being electropositive elements.	
	© small electron affinity.	
	d large atomic radius.	
2	Upon the classification of the elements,	Berzelius might have relied on
	a) their atomic numbers.	
	b) their electron configurations.	
	© their degree of electrical and heat cond	ductivity.
	d the quantum numbers of the last electrons	on in the atom of each of them.
•	3 Arsenic ₃₃ As and antimony ₅₁ Sb are sim	ilar in
	a being of the fourth period elements.	
	(b) being of group (5A).	
	© being better electrical conductors than	the other metals.
	d the four quantum numbers of the last e	electron in the atom of each of them.
Z	What is the element which can form an	ion with charge (-2) ?
	(a) Selenium 34Se	(b) Silicon ₁₄ Si
	© Strontium 38Sr	① Iodine ₅₃ I
6	Which of the following sets of elements	includes a nonmetal, a metal and a metalloid
	respectively ?	
	③ H, Zn, B	(b) Zn, I, Br
	© Zn, I, Se	(d) Te, Zn, Si

Which of the following shows the electron configuration of the most active metal and that of the most active nonmetal?

Choices	The most active metal	The most active nonmetal
(a)	[Ar], $4s^2$, $3d^I$	[Ar], $4s^2$, $3d^{10}$, $4p^6$
ь	[Xe], 6s ¹	$1s^2, 2s^2, 2p^5$
©	$1s^I$	$1s^2, 2s^2, 2p^3$
<u>d</u>	[Kr] , 5s ¹	[Ne], $3s^2$, $3p^5$

7	Chlorine gas	is less active	than fluorine	gas,	because	************
---	--------------	----------------	---------------	------	---------	--------------

- (a) the boiling point of chlorine is less than that of fluorine.
- (b) the molar mass of chlorine is less than that of fluorine.
- (c) the atomic radius of chlorine is larger than that of fluorine.
- (d) the electronegativity of chlorine is higher than that of fluorine.

The following figure represents a section in the periodic table :

							Α	
В				С	D			

What is the letter which refers to the element that is characterized by having a small atomic radius and not conducting electricity?

(a) A

(b) B

© C

(d) D

Acidic and basic property

Sulphuric acid does not react with

- (a) MgO
- ⊕ CO₂
- © Al₂O₃
- d Na₂O

What is the substance which dissolves in water forming an alkaline solution?

- (a) MgO
- (b) Al₂O₃
- © SiO₂

III Zinc oxide reacts with caustic soda as a (an)

amphoteric oxide.

(b) acidic oxide.

O basic oxide.

d neutral oxide.

Element (X) reacts with oxygen forming a gas whose aqueous solution to the the blue litmus paper into red.

What is the location of (X) in the periodic table?

- (a) 2nd period, group 1
- (b) 2nd period, group 2
- © 3rd period, group 16
- (d) 3rd period, group 2

(B) Among the properties of some nonmetallic elements are :

Property (1): One of its oxides dissolves in water forming a strong acid.

Property (2): Its last 3p sublevel does not contain any paired electrons.

Which of the following is (are) applicable for each of phosphorus ₁₅P and sulphur ₁₆S elements ?

Choices	Phosphorus	Sulphur
<u>a</u>	(1) and (2)	(1) only
Ъ	(1) only	(1) and (2)
0	(1) and (2)	(1) and (2)
a	(2) only	(1) only

The opposite table shows some elements of the third and the fourth periods in the periodic table.

3 rd period	Al	Si	P	S
4 th period	Ga	Ge	As	Se

What is (are) the element(s) of the fourth period whose oxide(s) dissolve(s) in water forming acidic solution ?

- (a) As and Ga
- (b) Ga and Ge
- © Ga and Se
- d Se only.

Here are 4 different compounds :

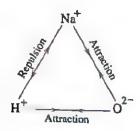
$$\begin{bmatrix}
 Na_2O
 \end{bmatrix}
 , \begin{bmatrix}
 Al_2O_3
 \end{bmatrix}
 , \begin{bmatrix}
 SO_2
 \end{bmatrix}$$

What is the number of each type of these compounds?

Choices	Acidic compounds	Basic compounds	Amphoteric compounds
(a)	1	2	I
Ъ	2	1	1
0	2	2	0
(1)	1	1	2

- What is the formula of the oxide of the element (M) which is located in group 1A in the periodic table ?
 - (a) M,O,
- **(**b) М₃О₂
- © MO
- (d) M₂O
- Why does aluminum oxide disappear on adding a little amount of it to sodium hydroxide solution with stirring?
 - (a) Because aluminum 13Al is located in the same period of sodium 11Na
 - (b) Because aluminum oxide reacts as a base with sodium hydroxide.
 - © Because the basic property decreases in the same period by increasing the atomic number.
 - d Because aluminum oxide reacts as an acid with sodium hydroxide.
- Is The four quantum numbers of the last electron in the atom of the element (X) are: $(n = 3, \ell = 0, m_{\ell} = 0, m_{s} = -\frac{1}{2})$.

 Which of the following represents the oxide of element (X)?
 - (a) Its formula is XO, it can react with the bases.
 - b Its formula is X2O, it can react with the bases.
 - © Its formula is XO, it can react with the acids.
 - d lts formula is X2O, it can react with the acids.
- 10 In the opposite figure,
 - (a) the attraction of O²⁻ to H⁺ ion increases.
 - b) the attraction of O2- to Na+ ion increases.
 - the strength of the bond between O2- and Na+ increases.
 - d an ionization occurs, and an acid is produced.



20	The strength of the oxyger	nated acids (oxyacids) depends on the number of the
1	(a) hydrogen atoms.	
	(b) oxygen atoms binded to	
	oxygen atoms nonbinded	
	hydrogen atoms nonbino	led to the nonmetal atoms.
2	What is the acid which the	ratio (n : m) in its hydroxy formula is (3 : 1)?
	ⓐ H₄SiO₄	⊕ H ₃ PO ₄
	© H ₂ SO ₄	(d) HClO ₄
25	The weakest oxygenated	acid in the fourth period in the periodic table is
	(a) Ge(OH) ₄	(b) BrO₃(OH)
	© AsO(OH) ₃	(d) SeO ₂ (OH) ₂
23	Among the strong acidic s	colutions is
	(a) SO ₂ (OH) ₂	(b) PO(OH) ₃
	© Ca(OH) ₂	(d) Al(OH) ₃
24	Which of the following ox	ygenated acids is the strongest?
	(a) HOCl	(b) HNO ₂
	© H ₂ SO ₃	(d) HNO ₃
25	Perchloric acid is a	****
	(a) monohydric acid.	(b) dihydric acid.
	© trihydric acid.	d) tetrahydric acid.
26	Element (M) is located in	
		roxy formula of its oxygenated acid ?
	(a) M(OH) ₄	(b) MO(OH) ₃
	© MO ₂ (OH) ₂	
		Essay questions
2	Demonstrate with the bal	anced symbolic equations :
	(1) The dissolution of sulph	nur trioxide gas in water.
	(2) Carbon dioxide gas is a	n acidic oxide.
	(3) The dissolution of pota	ssium oxide in water.
	(4) Sodium oxide is a basic	c oxide.
	(5) The reaction of sodium	oxide with hydrochloric acid.
	(6) Zinc oxide is an ampho	oteric oxide.

The opposite table represents the quantum numbers of the last electron in the atom of each of (X) and (Y) elements:

(1)	Write	the	electronic	configurations
	of the	two	elements.	

(2) Which of them	is	electropositive	?	Explain.
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Florent	Quantum number.					
Element	(n)	(1)	(\mathbf{m}_l)	(3)		
(X)	3	1	0	$-\frac{1}{2}$		
(Y)	3	0	0	+1/2		

- Aluminum oxide reacts with sodium hydroxide forming sodium aluminate whose molecule contains a sodium atom, an aluminum atom and two oxygen atoms.

 Write the balanced symbolic equation which represents the reaction of aluminum oxide with:
 - (1) Sodium hydroxide.
 - (2) Sulphuric acid.
- Why does cesium hydroxide ionize as a base, while ClO₃(OH) ionizes as an acid?
- 31 The following table represents the third period in the modern periodic table :

1	IA	IIA	ША	IVA	VA	VIA	VIIA	0
	A	В	C	D	E	Х	Υ	Z

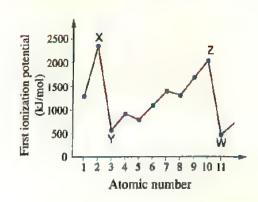
- (1) What is the number of oxygen atoms nonbonded to hydrogen in the strongest oxygenated acid of the element (Y)?
- (2) Why is the oxide of the element (A) basic oxide?

Higher – order questions Answered in detail

Choose the correct answer:

- Which of the represented elements in the shown graph loses its

 Valence electrons more easily?
 - (3) X
 - (b) Y
 - $\odot z$
 - (d) W



المعاصر .كيمياء ـ لغات (شرح) / ٢٦ (م: ٢٣)

A mixture is composed of the oxides of two elements which are located in the third period in the periodic table, and after their reaction together, the product dissolves in water forming an almost neutral solution.

What are the two oxides composing this mixture?

- (3) Al₂O₃ and N₂O
- (b) Na,O and MgO
- Na,O and SO,
- (d) SO₃ and P₂O₅
- What is the probable electronic configuration of the last sublevel in the atom of the element (M) whose oxygenated acid has the formula $MO_2(OH)_2$?
 - (a) $3p^2$

(b) $3p^3$

(L) 3p4

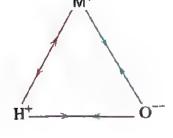
- (d) $3p^5$
- What is the anion which forms the strongest oxygenated acid?
 - (a) SO₄²-
- (b) C10,
- © ClO₃
- (d) CIO₄
- In the opposite figure, if the bond (O H)
 is stronger than the bond (M O), then
 the electron configuration of
 the element (M) may end with the sublevel



(b) 152

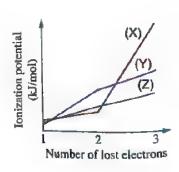
© $2p^2$

(d) $2p^{I}$



Essay question:

replace the letters (X), (Y) and (Z) with what is suitable from the elements 12Mg, 13Al and 19K and arrange them according to the metallic property.



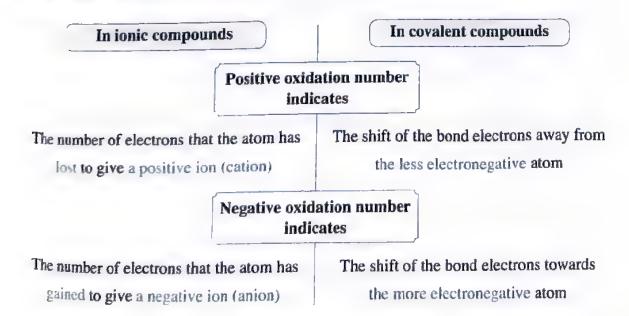


Oxidation numbers (states)

Oxidation number is a number that refers to the electric charge (positive or negative) that the atom or ion would carry in the compound, whether it is an ionic or a covalent compound.

The significance of oxidation numbers:

The significance of positive and negative oxidation numbers in the ionic compounds differs from that of the oxidation numbers in the covalent compounds.



Rules for calculating the oxidation numbers



Rule

Application

The oxidation number of the element atom in the molecule of similar atoms equals zero, whatever the number of the molecule atoms .. G.R.?

Because the sharing of electrons between the atoms is equal.

Molecule	Na	Cl ₂	P ₄	S ₈
Oxidation number of element atom		ZE	ro	

The oxidation number of the element ion equals the charge (valence) of the ion.

lon	Ag^{+}	Cu ²⁺	Fe ³⁺	CI ⁻	O ² -	N ³ -
Oxidation no-	+1	+2	+3	-1	-2	-3

The oxidation number of the atomic group equals the charge of the group.

Atomic group	(NH ₄) ⁺ Ammonium gp.			(CO ₃) ²⁻ Carbonate gp.		
Oxidation no.	+1	-1	-1	-2	-2	-3

- The oxidation number of any metal in :
- Compound molecule

Oxidation no. of the metal

KNO ₃	MgSO ₄	AICl ₃
+1	+2	+3

KF

OF,

- Group 1A elements equals +1
 Group 2A elements equals +2
- Group 3A elements equals +3

Ð	The oxidation number of
	fluorine in all its compounds
	equals -1 G.R.?

Because its electronegativity is greater than that of all other elements, and it tends to gain or to share le.

Compound molecule	HF
Oxidation no. of fluorine	

The oxidation numbers of chlorine, bromine and iodine (halogens) in most of their compounds equal (-1), however their other oxidation numbers can be calculated mathematically.



- The oxidation number of oxygen in most of its compounds is -2, while its oxidation number in:
 - Peroxides equals -1
 - Superoxides equals $-\frac{1}{2}$
 - Its compound with fluorine equals +2

• Oxide	Normal oxide	Peroxide		Peroxide		Super-	With harn	
Formula	Na ₂ O	H ₂ O ₂	Na ₂ O ₂	KO ₂	OF ₂			
Oxidation no. of oxygen	-2	and the second	-1	-12	+2	wiegen megepangigan extres beid		

The oxidation number of hydrogen in most of its compounds is +1, except in its compounds with active metals which are known as active metal hydrides, its oxidation number is -1

Compound molecule	HCI	NaH	CaH ₂	AlH ₃
Oxidation no. of hydrogen	+1	_1	-1	-1

Active metal hydrides are ionic compounds formed from the combination of an active metal with hydrogen in which hydrogen has an oxidation number -1 (negative ion).

The algebraic summation of the oxidation numbers of the different atoms in the molecule equals zero.

In sodium chloride molecule NaCl:

The oxidation no. of Na (+1) + The oxidation no. of Cl (-1)

= zero

The algebraic summation of the oxidation numbers of the atomic groups forming the molecule equals zero.

In the molecule (NH₄)⁺(NO₂)⁻:

The oxidation no. of ammonium group (+1) +

The oxidation no. of nitrite group (-1) = zero

The algebraic summation of the oxidation numbers of the different atoms in an atomic group equals the charge of the group.

In hydroxide group OH ::

The oxidation no. of oxygen (-2) +

The oxidation no. of hydrogen (+1) = -1

Some elements, especially the transition elements have several oxidation numbers which can be calculated by knowing the oxidation numbers of the other elements.

Application.

Hydrogen gas evolves

At the anode (the positive electrode)
during the electrolysis of sodium hydride melt

At the cathode (the negative electrode) during the electrolysis of the acidified water

Because

The oxidation number of hydrogen in sodium hydride NaH melt is (-1)

(i.e. a negative hydrogen ion)

The oxidation number of hydrogen in acidified water H₂O is (+1)

(i.e. a positive hydrogen ion)

How to assign the oxidation number of an unknown element in a given compound or atomic group

Steps	Compound	Atomic group	
Write the oxidation number of each known element above its atom symbol in the compound molecule or atomic group formula.	+1 ? -2 -2 K ₂ Cr ₂ O ₇	$(\overset{?}{CO_3})^{2-}$	
Multiply the oxidation number of each element by the number of its atoms in the molecule.	$\begin{array}{ccc} K_2 & \operatorname{Cr}_2 & \operatorname{O}_{\gamma} \\ \text{(1 x 2)} & \text{(-2 x 7)} \end{array}$	(CO ₃) ²⁻ (-2×3)	
Assign the oxidation number of unknown element knowing that:		· -	
 The algebraic summation of the atoms of the different elements in the molecule equals zero. The algebraic summation of the atoms of the different elements in the atomic group equals the charge of the group. 	2 + 2Cr - 14 = 0 2Cr = +12 Cr = +6	C + (-6) = -2 C = 6 - 2 C = +4	

Worked Examples

Calculate the oxidation number of :

- (1) Chlorine in: (i) Cl₂
- (ii) KClO₄
- (2) Sulphur in : (i) (SO₄)²⁻
- (ii) Na₂S₂O₃
- (3) Chromium in : $Cr_2(SO_4)_3$
- (4) Nitrogen in : (NH₄)⁺(NO₂)⁻

Answer:

(1) (i)
$$2Cl = 0$$

(ii)
$$\frac{+1}{K} \cdot \frac{-2}{Cl}$$
, $1 + Cl + (-2 \times 4) = 0$, $Cl - 7 = 0$: $Cl = +7$

$$Cl-7=0$$
 :: $Cl=+7$

$$S + (-2 \times 4) = -2$$

(2) (i)
$$(SO_4)^{2-}$$
, $S + (-2 \times 4) = -2$, $S = -2 + 8$: $S = +6$

(ii)
$$Na_2S_2O_3$$
 , $(+1 \times 2) + 2S + (-2 \times 3) = 0$, $2S = +4$ $\therefore S = +2$

$$\therefore$$
 S = +2

(3)
$$C_{r_2}(SO_A)_3^{2-}$$

$$2Cr + (-2 \times 3) = 0$$

(3)
$$Cr_2(SO_4)_3^{2-}$$
, $2Cr + (-2 \times 3) = 0$, $2Cr = +6$ $\therefore Cr = +3$

(4) (NH₄)⁺(NO₂)⁻ is an ionic compound which consists of two atomic groups, the oxidation number of nitrogen in each of them is different.

$$N + (+1 \times 4) = +1$$

$$(NH_A)^+$$
, $N + (+1 \times 4) = +1$, $N = 1 - 4$: $N = -3$

$$(NO_2)^-$$
 , $N + (-2 \times 2) = -1$

$$N = -1 + 4 : N = +3$$

10 The nucleus of manganese atom Mn contains 25 protons.

What is the electron configuration of manganese in $Mn_3(PO_4)_2$?

Idea of answering :-

The oxidation number of manganese in Mn₃(PO₄)₂:

$$3Mn + (2 \times -3) = 0$$

$$\therefore$$
 Mn = +2

The electron configuration of manganese atom is:

$$_{25}$$
Mn: [Ar], $4s^2$, $3d^5$

. The electron configuration of Mn²⁺ ion is:

$$Mn^{2+}: [Ar], 3d^5$$

Answer: The correct choice is (b)

Test Yourself

What are the two ions which form the compound Li3N?

(a) Li⁺, N³⁻

(b) Li3+, N-

CLi+, N

(d) Li^{3+} , N^{3-}

Idea of answering:

- : The oxidation number of lithium in its compounds is
- : The choices _____ and ____ are excluded.
- \because The oxidation number of nitrogen in Li₃N is:

$$(3\times +1)+N=0$$

- : N =
- .. The choice is excluded.

Answer: The correct choice is

Worked Example

The opposite table shows the oxidation numbers of three elements A, B and C in a compound.

What is the probable molecular formula of this compound?

Idea of answering:

- : The algebraic summation of the oxidation numbers of the atoms composing the compound must equal zero.
- ... The probable molecular formula is the one in which the algebraic summation of the oxidation numbers of the atoms equals zero.

a	A ₃ (B ₄ C) ₂	$(+2 \times 3) + (+5 \times 4 \times 2) + (-2 \times 2) = 6 + 40 - 4 = +42$	X
(b)	A ₂ (BC ₄) ₂	$(+2 \times 3) + (+5 \times 2) + (-2 \times 4 \times 2) = 6 + 10 - 16 = 0$	1

Answer: The correct choice is b.

Oxidation number

+2

+5

-2

Element

A

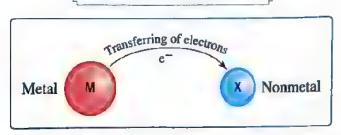
В

C

Calculating the change of the oxidation number in an oxidation-reduction reaction (redox reaction)

• The advantage of using oxidation numbers is that they can help us in determining the type of chemical change occurring to an element during the chemical reaction.

In the chemical reaction



The metal loses one or more electrons (undergoes oxidation).

, so its oxidation number increases.

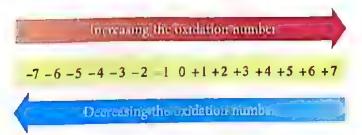
The nonmetal gains one or more electrons (undergoes reduction).

, so its oxidation number decreases.

The metal in this case is the reducing agent. : The nonmetal in this case is the oxidizing agent.

-Oxidation-

It is the process of losing electrons resulting in increasing the positive charge or decreasing the negative charge



Reduction -

It is the process of gaining electrons resulting in decreasing the positive charge or increasing the negative charge

Oxidation-reduction process involves changing in the oxidation numbers

Note

In the balanced equation

Number of the moles of electrons lost by the metal (M)

Number of the moles of electrons gained by the nonmetal (X)

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Test Yourself

In the equation : $4Al + 3O_2 \longrightarrow 2Al_2O_3$, when aluminum atoms lose 12 mol of electrons, so oxygen atoms

- (a) gain 4 mol of electrons.
- (b) gain 12 mol of electrons.
- (c) lose 4 mol of electrons.

(d) lose 12 mol of electrons.

Idea of answering:

- : No. of moles of the electrons lost by aluminum =
- .. No. of moles of the electrons gained by oxygen =

Answer: The correct choice is

Worked Examples

DEach of the following changes represents either an oxidation or a reduction reaction, except

$$\bigcirc N_2O_4 \longrightarrow NO_2$$

$$\textcircled{d} V_2 O_3 \longrightarrow V_2 O_5$$

Idea of answering :-

(a)
$$CO_2$$
 CO_2 $CO_$

- (CIO²) C1 + (-2) = -1Oxidation process
- : Carbon underwent a reduction process, : Chlorine underwent an oxidation process. as its oxidation no. decreased from +4 to +2
 - as its oxidation no. increased from +1 to +1
- ... The choice (a) is excluded.
- ... The choice (b) is excluded.

 N_2O_4 (c) $2N + (-2 \times 4) = 0$ $N + (-2 \times 2) = 0$ 2N = +8N = +4

 Neither oxidation nor reduction occurred, because there is no change in the oxidation number of nitrogen.

Answer: The correct choice is (e)

© Elucidate the type of change (oxidation or reduction) that occurred to each of here are carbon in the following reaction:

$$Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2$$

Answer:

$$\stackrel{?}{\text{Fe}}_{2}\stackrel{-2}{\text{O}_{3}} \longrightarrow \stackrel{0}{\text{Fe}}$$

$$2\text{Fe} + (-2 \times 3) = 0$$

$$2\text{Fe} = +6$$

$$\text{Fe} = +3$$

$$\stackrel{\text{Reduction process}}{\text{Reduction process}}$$

Reduction process occurred to iron,
where the oxidation number of iron
decreased from +3 to 0

$$\begin{array}{ccc}
? & -2 & & ? & -2 \\
CO & & \longrightarrow & CO_2
\end{array}$$

$$C + (-2) = 0 & C + (-2 \times 2) = 0$$

$$C = +2$$
 $C = +4$
Oxidation process

Oxidation process occurred to carbon, where the oxidation number of carbon increased from +2 to +4

Elucidate the change (whether oxidation or reduction) that occurred to each of chromium and iron in the following reaction :

$$K_2Cr_2O_7 + 6FeCl_2 + 14HCl \longrightarrow 2KCl + 2CrCl_3 + 6FeCl_3 + 7H_2O$$

Answer:

$$^{+1}_{K_2}$$
Cr₂O₇ $\xrightarrow{\qquad}$ $^{?}_{Cr}$ Cl₃
 $^{(+1 \times 2)} + 2Cr + (-2 \times 7) = 0$ $Cr + (-1 \times 3) = 0$
 2 Cr = +12

 $Cr = +6$ $Cr = +3$

Reduction process

Reduction process occurred to chromium, because the oxidation number of chromium decreased from +6 to +3

$$\frac{? -1}{\text{FeCl}_2} \longrightarrow \frac{? -1}{\text{FeCl}_3}$$

$$\text{Fe} + (-1 \times 2) = 0 \qquad \text{Fe} + (-1 \times 3) = 0$$

Fe =
$$+2$$
 Fe = $+3$
Oxidation process

Oxidation process occurred to iron, because the oxidation number of iron increased from +2 to +3

What are the oxidizing and the reducing agents

in the reaction : $2H_2S + SO_2 \longrightarrow 2H_2O + 3S$?

Choices	Oxidizing agent	Reducing agent
(a)	SO ₂	S
(b)	H ₂ S	SO ₂
©	S	H ₂ S
(1)	SO ₂	H ₂ S

Idea of answering:

- : Sulphur in H₂S underwent an oxidation process, as its oxidation number increased from -2 to 0
- .. H₂S is the reducing agent.
- .. The choices (a) and (b) are excluded.

- $H_2^{+1} \stackrel{?}{S} \longrightarrow S$ $(+1 \times 2) + S = 0$ $S = -2 \qquad S = 0$ Oxidation
- Sulphur in SO₂ underwent a reduction process, as its oxidation number decreased from +4 to 0
- ∴ SO₂ is the oxidizing agent.

Answer: The correct choice is (d)

$$\begin{array}{c}
?-2 \\
SO_2
\end{array}$$

$$S + (-2 \times 2) = 0$$

$$S = +4 \qquad S = 0$$
Reduction

ODeduce the values of "n" in the following reactions:

(1)
$$S^{6+} + ne^{-} \longrightarrow S^{2-}$$

(2)
$$2Br^n - 2e^- \longrightarrow Br_2$$

Answer:

(1)
$$6 + (n \times -1) = -2$$
 , $6 - n = -2$

(2)
$$2n - (2 \times -1) = 0$$
 , $2n + 2 = 0$, $2n = -2$

$$\therefore$$
 n = -1

Multiple thorre question





		April 1 are April 2 are	· (13.00
The oxidation num	ber of hydrogen equa	ls (–1) in	
② CaH₂	⊕ H ₂ O	© H ₂ O ₂	(d) HCl
During the electrol	ysis of all the following	ng compounds, hyd	rogen gas evolves at
the anode, except	************		
(a) H ₂ O	(b) CaH ₂	© NaH	d LiH
The oxidation number	ber of sodium in sodiu	ım peroxide Na ₂ O ₂	equals ······
(a) -2	(b) -1	©+1	d +2
What is the oxidati	on number of oxygen	in OF ₂ ?	
a -1	(b) +1	© +2	<u>(d)</u> –2
The oxidation numb	per of phosphorus in p	ohosphate ion (PO	_v) ³ - is
a) +3	(b) +5	© +8	<u>(d)</u> –3
The summation of t	he oxidation numbers	of both oxygen a	nd hydrogen in H ₂ O
equals			
a 0	6 -4	© <i>-</i> 2	(d) +4
What is the oxidation	on number of the tran	sition metal in Al ₂	(CrO ₄) ₃ ?
(a) +3	(b) +5	©+6	d +7
What is the oxidation	n number of phospho	orus in pyrophosph	ate ion $(P_2O_7)^{4-}$?
(a) +3.5	(b) +5	© +7	(1) +10
In which pair of the	following does nitrog	jen have the same	oxidation number ?
¹ N ₂ O ₅ , HNO ₃	ⓑ HNO ₂ , NO	© NO ₂ , N ₂	$\textcircled{1}$ HNO $_3$, HNO $_2$

10 What is the electron	ic configuration of ma	nganese [₂₅ Mn] in N	$Mn_2(SO_4)_3$?
(a) [Ar] ,3d ⁶	\bigcirc [Ar], $3d^4$	© [Ar], $4s^2$, $3d^2$	(1) [Ar], $4s^2$, $3d$
11 The electron configu	ration of oxygen ion i	n Na ₂ O ₂ is	
(a) Is^2 , $2s^2$, $2p^6$	ⓑ $1s^2$, $2s^2$, $2p^4$	© $1s^2$, $2s^2$, $2p^3$	(d) $1s^2$, $2s^2$, $2p^5$
12 The conversion of in	on (III) ion into iron (II) ion is a (an)	***
a excitation process	•	(b) oxidation proces	SS.
© reduction process		d loss of electron	process.
When aluminum is o	oxidized forming Al ⁴⁺	ion, it loses the last o	electron from
the sublevel	401		
(a) 1s	(b) 2s	© 2p	(1) 3s
Which of the follow	ring elements is easier	to be oxidized?	
(a) Sulphur.	(b) Magnesium.	© Boron.	(d) Argon.
15 What is the symbol	of the element which	is the strongest redu	icing agent in
the period that con	tains the element whi	ch has the highest el	ectronegativity
in the modern perio	odic table ?		
②₃Li	(b) 11 Na	© ₁₈ Ar	(1) 19K
16 When (MnO ₄) ⁻ read	cts and is converted to	Mn ²⁺ , (MnO ₄) ⁻ is .	*******
oreduced, as the o	xidation number of ma	nganese increases.	
(i) oxidized, as the	oxidation number of m	anganese increases.	
© reduced, as the o	xidation number of ma	inganese decreases.	
(i) oxidized, as the	oxidation number of m	anganese decreases.	
Which of the follow	ing reactions represe	nts an oxidation-red	uction reaction ?
(a) CuO + H ₂ SO ₄ -	CuSO ₄ + H ₂ O		
⊕ CaCO ₃ + 2HCI	CaCl ₂ + H ₂ O	+ CO ₂	
$\bigcirc (Cr_2O_7)^{2-} + 3H_2$	$S + 8H^+ \longrightarrow 2Cr^3$	$^{+} + 3S + 7H_{2}O$	
(d) NaCl + AgNO ₃	→ AgCl + NaNo	O_3	

All the following reactions are oxidation-reduction reactions, except

(a) $CH_4 + Br_2 \longrightarrow CH_3Br + HBr$ (b) $2Na + 2H_2O \longrightarrow 2NaOH + H$

in each of the following conversions the oxidation number of nitrogen changes,

except

② NO₃ → NO

(b) N₂O₄ ---- NO₃

(c) NH₂ ---- (NH₄)+

(1) NO, ---- N,O,

 $\overline{f m}$ In which of the following changes an oxidation process occurs to vanadium ${f V}$?

(a) $VO_2 \longrightarrow V_2O_3$

 $\bigcirc V_2O_5 \longrightarrow VO_2$

© V,O, → VO

 $\textcircled{d} V_2O_3 \longrightarrow V_2O_5$

In the reaction : $Cl_2 + 2\Gamma \longrightarrow I_2 + 2C\Gamma$

Which of the following is the reducing agent?

(a) Chloride ions.

(b) Chlorine gas. (c) Iodide ions.

(d) Iodine vapour.

In which of the following equations the underlined substance acts as a reducing agent?

(a) $CaO + H_2O \longrightarrow Ca(OH)_2$

 $(b) CO_2 + C \longrightarrow 2CO$

© $\underline{\text{CuO}} + \text{H}_2 \longrightarrow \text{Cu} + \text{H}_2\text{O}$

d 3CO + Fe₂O₃ \longrightarrow 2Fe + 3CO₂

49 In the reaction: $2ClO_3^- + 7Cl^- \longrightarrow 3Cl_2 + 3ClO_2$

Which of the following statements represents this reaction?

- Oxygen is reduced and chlorine is oxidized.
- (b) Oxygen is oxidized and chlorine is reduced.
- () Chlorine is oxidized and reduced.
- ① Oxygen is oxidized and reduced.
- In the chemical reaction represented by the following chemical equation:

$$Ni_{(s)} + 2HCI_{(gq)} \longrightarrow NiCI_{2(gq)} + H_{2(g)}$$

What does happen to nickel Ni atom?

Loses le

(b) Gains le

© Loses 2e

(d) Gains 2e⁻

In the following oxidation-reduction reaction:

$$2Cr_{(aq)}^{3+} + 3Cl_{2(aq)} + 7H_2O_{(\ell)} \longrightarrow Cr_2O_{7(aq)}^{2-} + 6Cl_{(aq)}^{-} + 14H_{(aq)}^{+}$$

Which of the following loses electrons?

- (a) Cl₂
- (b) Cr³⁺
- © H₂O
- In the opposite redox reaction : $Fe^{3+} + Al \longrightarrow Fe + Al^{3+}$

The electrons transfer from

(a) Fe³⁺ — Al

(b) Al → Fe³⁺

© Fe — Fe³⁺

- $(d) Al^{3+} \longrightarrow Al$
- in the process represented by the reaction: $CIO^{-} \longrightarrow CIO_{3}^{2-}$ Which of the following about chlorine is correct?

Choices	Electrons	Ionic size
(a)	It gains 3 electrons	Decreases
Ь	It gains 3 electrons	Increases
0	It loses 3 electrons	Decreases
(d)	It loses 3 electrons	Increases

28 When NO2 reacts and is converted to N2O4

The oxidation number of nitrogen

- (a) increases by 2

- (b) increases by 4 (c) increases by 8 (d) does not change.
- The table shows the first four ionization potentials of the elements (X) and (Y):

Element	1 st ionization potential	2 nd ionization potential	3 rd ionization potential	4 th ionization potential
(X)	+590 kJ/mol	+1145 kJ/mol	+4912 kJ/mol	+6491 kJ/mol
(Y)	+1314 kJ/mol	+3388 kJ/mol	+5301 kJ/mol	+7469 kJ/mol

Which of the following describes the elements (X) and (Y)?

On the combination of

- (a) element (X) with hydrogen, the oxidation number of hydrogen is +1
- (b) element (Y) with hydrogen, the oxidation number of hydrogen is -1
- © element (Y) with element (X), element (X) is reduced.
- (d) element (X) with element (Y), element (Y) acts as an oxidizing agent.



Give reason:

- (1) The oxidation number of fluorine in all compounds is always negative.
- (2) Hydrogen gas evolves at the anode during the electrolysis of calcium hydroxide melt.

Calculate the oxidation number of :

(1) Hydrogen in : (i) KOH (ii) KH	(2) Oxygen in : (i) KO ₂ (ii) Li ₂ O
(3) Chlorine in :	(4) Sulphur in :
(i) Cl ₂ (ii) KClO ₄	(i) NaHSO ₄ (ii) $(SO_3)^{2-}$

(BrO) ion is converted to (BrO₃)²⁻ ion.

Is this conversion an oxidation or a reduction? Explain.

- Calculate the oxidation number of zinc in sodium zincate.
- Determine the oxidizing agent and the reducing agent in the following reaction :

$$2H_2S + SO_2 \longrightarrow 2H_2O + 3S$$

55 In the reaction:

$$Cr_2O_7^{2-} + 3H_2S + 8H^+ \longrightarrow 2Cr^{3+} + 3S + 7H_2O$$

- (1) State the reducing agent and the oxidizing agent.
- (2) How many electrons are lost? What is their source?

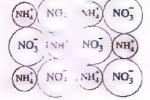
The following figure represents a section in the modern periodic table :



Which of the illustrated elements:

- (1) Is characterized by several oxidation states, with mentioning them.
- (2) Has an oxidation state -1 in the active metals hydrides.

of an ammonium nitrate crystal. Determine the oxidation number of nitrogen in:



- (1) The anion.
- (2) The cation.

Higher - order questions Answered in detail

Choose the correct answer:

38 The following equation represents an oxidation-reduction reaction:

$$4H_2SO_4 + 3H_2S + K_2Cr_2O_7 \longrightarrow 7H_2O + K_2SO_4 + 3S + Cr_2(SO_4)_3$$

What is the number of moles of sulphur atoms which are exposed to an oxidation process in this equation?

(a) I

- **(b)** 3
- ©4
- **d**)7

Essay question:

- of the last electron in the atom of each of 4 elements:
 - (1) Which of the elements shown in the table:
 - (i) Reduces hydrogen upon combining with it.
 - (ii) Is the strongest oxidizing agent.
- (2) What is the oxidation number of element (Z) when it combines with element (W)?

Exam model



on Chapter 2



Choose the correct answer for the questions 11: 20.







Each of the following statements shows the correct graduation of the mentioned property in the representative elements, except



(a) electron affinity ($_{8}O < _{16}S < _{9}F < _{17}CI$).

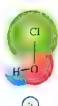
(b) ionic radius
$$({}_{8}O^{2-} < {}_{16}S^{2-} < {}_{9}F^{-} < {}_{11}Na^{+})$$
.

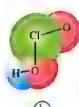
- © acidic property (HF < HCl < HBr < HI).
- d the oxidation number of oxygen $(MgO < Na_2O_2 < KO_2 < OF_2)$

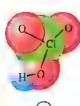
Which of the following oxides react together when dissolved in water?

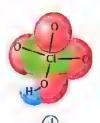
- (d) Al₂O₃, ZnO
- (b) Na,O, MgO
- O Na2O, P2O5
- d SO₃ , P₂O₅

Which of the following oxygenated acids has the lowest $\frac{m}{n}$ value ?











- (a) the atomic size decreases.
- (b) the ionization potential decreases.
- © the electronegativity decreases.
- the nuclear charge decreases.

(5) The following table exhibits the electron configurations of 4 different elements:

$[Kr], 4d^{10}, 5s^2$	$[Kr], 5s^2, 4d^{10}, 5p^6, 6s^2$
[Xe], $6s^2$, $4f^{14}$, $5d^{10}$, $6p^6$, $7s^1$	[Xe], $4f^{14}$, $5d^{1}$, $6s^{2}$

What is the number of the elements which are located in s-block?

(a) 1

(b) 2

(c) 3

- **(1)** 4
- In which of the following is the summation of the two oxidation numbers of manganese and nitrogen each in its compound the least ?

Choices	Manganese compound	Nitrogen compound
(a)	MnCl ₄	N ₂
(b)	MnCO ₃	NO_2^-
0	K ₂ MnO ₄	NH_4^+
(d)	Mn(OH) ₃	NH ₂ OH

- Which of the following statements is correct?
 - The element with the atomic number 80 is located in the 6th period, group (1B).
 - The element with the atomic number 38 is located in the 6th period, group (2B).
 - The element with the electronic configuration: [Xe], $4f^{14}$, $5d^5$, $6s^2$ is located in 6^{th} period, group (7B).
 - ① The element with the electronic configuration: [Ar], $3d^{10}$, $4s^2$, $4p^4$ is located in 4^{th} period, group (6B).
- What are the two metals whose oxides can react with both acids and alkalis?
 - Na , Zn

(b) Mg, Al

Mg, Be

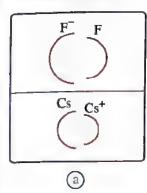
- (d) Al, Zn
- Which of the following represents the proper graduation of the electronegativities of the elements $\binom{4X}{12}Y/\binom{5Z}{16}M$?
 - \bigcirc Y < X < Z < M

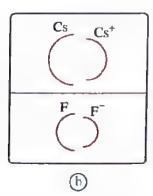
 \bigcirc M < Z < Y < X

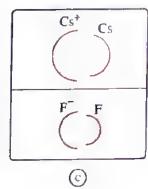
 \odot X < Z < Y < M

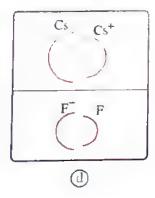
 \bigcirc M < Y < X < Z

Which of the following represents the correct relation between the atomic radius and ionic radius ?



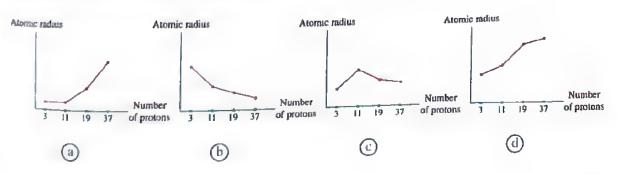






- Mhich of the following statements is correct?
 - (3) Lanthanum 57La and actinium 89Ac do not belong to lanthanides and actinides.
 - (b) The element whose atomic number is 31 is located in the third period.
 - © The electron configuration of $_{27}$ Co does not follow the system: $ns^{1:2}$, $(n-1)d^{1:10}$
 - (d) All actinides are synthesized.
- Element (X) is located in the fourth period, group (15) in the modern periodic table.

 Which of the following represents the electron configuration of the last energy level in its atom?
 - (a) d orbitals are half filled and s orbital is completely filled.
 - (b) s orbital is completely filled and p orbitals are half filled.
 - © d orbitals are occupied by electrons and s orbital is half filled.
 - (d) p orbitals are half filled and s orbital is half filled.
- Which of the following graphical figures represents the graduation of the atomic radii of the elements of group (1 A) ?



The opposite table shows the first five ionization potentials of the element (X).

Ionization potential (kJ/mol)				
First	Second	Third	Fourth	Fifth
+738	+1451	+7733	+10541	+13629

What is the number of the group of

the element (X) in the modern periodic table ?

(a) 1

(b) 2

(c) 13

- d) 14
- What is the oxidizing agent in the reaction: $Cu + 2Ag^+ \longrightarrow Cu^{2+} + 2Ag$?
 - (a) Cu

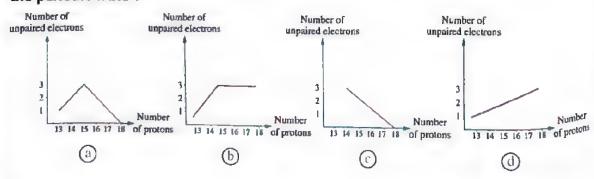
(b) Ag⁺

© Cu²⁺

- d Ag
- In the reaction : $3NaClO \xrightarrow{\Delta} 2NaCl + NaClO_3$ Which of the following choices represents the oxidation numbers of chlorine in the three compounds ?

Choices	NaClO	NaCl	NaClO ₃
a	-1	-1	+5
Ъ	+1	-1	+5
0	+1	-1	+7
(1)	+2	+1	+7

Which of the following graphical figures represents the number of the unpaired electrons in the orbitals of *3p* sublevel in the elements of the third period in the periodic table ?



(18) In the following equations:

(1)
$$Na_{(g)} \longrightarrow Na_{(g)}^+ + e^-$$

$$\Delta H = W$$

(2)
$$Na_{(g)} \longrightarrow Na_{(g)}^{2+} + 2e^{-}$$

$$\Delta H = x$$

(3)
$$Na_{(s)} \longrightarrow Na_{(g)}$$

$$\Delta H = y$$

(4)
$$Na_{(s)} \longrightarrow Na_{(g)}^{2+} + 2e^{-}$$

$$\Delta H = 2$$

Which of the following equations represents the second ionization potential of sodium?

- (a) Equation (2) × Equation (1).
- ⓑ Equation (2) Equation (1).
- © Equation (3) Equation (1).
- d Equation (4) Equation (3).
- The electronic configuration : [Xe] $,6s^2$ $,5d^{10}$ $,4f^{14}$ $,6p^3$ represents
 - (a) an inner transition element.
 - (b) a main transition element.
 - © a representative element.
 - d a noble element.
- (1): Number of protons in Mg^{2+} is higher than that in Al^{3+}
 - (2) : Number of neutrons in each of Mg^{2+} and Al^{3+} is higher than the number of protons in each of them.
 - (3) : The electronic configurations of Mg^{2+} and Al^{3+} are similar.
 - (4): Numbers of neutrons in both of Mg^{2+} and Al^{3+} are equal.

Which of these statements represent $^{27}_{13}\mathrm{Al}^{3+}$ and $^{26}_{12}\mathrm{Mg}^{2+}$ ions ?

(1) and (2) only.

(b) (1) and (3) only.

(c) (3) and (4) only.

(d) (2), (3) and (4).

Answer the essay questions 21: 23



21) Two compounds HIO and $HClO_3$,

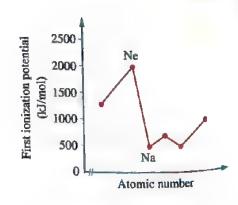
Which of them is more acidic? Explain.

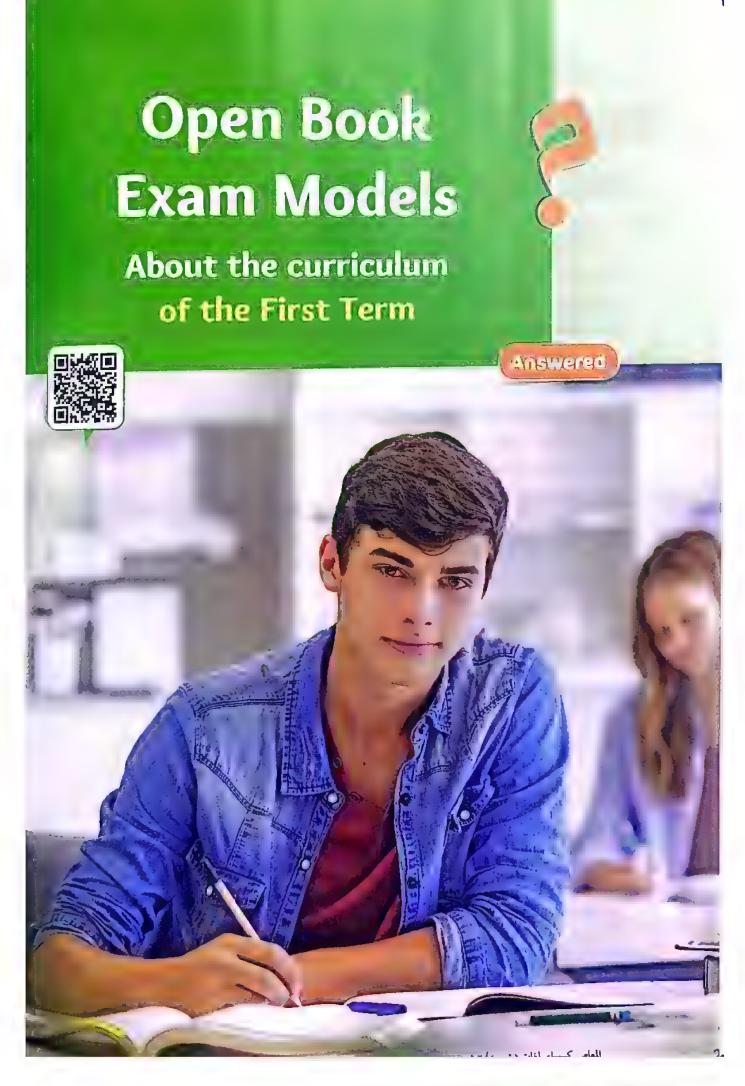
What is meant by that the bond length in NaCl = 2.79 Å?

23 The opposite figure represents

the first ionization potentials of some elements of the second and the third periods.

Why is the first ionization potential of neon higher than that of sodium?





Questions of



2021 Exam

Answered

_	Choose the correct answer for the following questions:
1	The properties of the cathode rays differ from those of alpha rays in
	a that they can be observed through flashes.
	b) that they both move in straight lines.
	© that they both are particles.
1	d the direction of their deflection in an electric field.
(2)	Bohr's and Rutherford's models are similar in that
	a) the electron can gain a quantum of energy.
	b the electron can not be found within the regions between the energy levels.
	c the electron orbits the nucleus in definite constant orbits.
	d the electron is a negatively charged particle.
(3)	Which of the following properties is not among those of the line spectrum?
	(a) It consists of coloured lines separated by lighted areas.
	(b) It arises from the return of the excited electron to its level.
	() It is produced through heating the atoms of the elements in the state of gas or vapour.
	d Each element has a characteristic line spectrum.
1	The opposite figure shows the probabilities of finding
	the electron in the atom. The most accurate choice is
	The most accurate choice is
	(a) B, C and D are consistent with Bohr's model. K L M
	(b) A, C and D are consistent with the modern atomic theory.
	© B, C and D are consistent with the modern atomic theory.
	(d) A, B and C are consistent with Bohr's model.
(5	Among the modifications of the wave mechanical theory on Rutherford's model
	is
	a) that the nucleus of the atom is positively charged.
	(b) that the atom is electrically neutral.
	c) that the atom is not solid but contains a vast space.
	d the probability of finding the electron in the spaces around the nucleus.

- The values of the sublevels of a மாக்குட்டாளரு என எற்று மு 2 This principal level is
 - (a) L
 - (c) K

 \bigcirc M

or Bull Story

- The electron configuration of an atom ends with the sublevel $4d^2$, the number of the orbitals which are occupied by electrons in the principal level n = 4 is
 - (a) 7

(b) 4

© 6

- **(1)** 5
- If l = 2, then the values of m_l and m_s of the first electron in the sublevel are
 - (a) $m_{\ell} = +2$, $m_{s} = +\frac{1}{2}$
 - (b) $m_{\ell} = -1$, $m_{s} = -\frac{1}{2}$
 - © $m_{\ell} = -2$, $m_{s} = +\frac{1}{2}$
 - (d) $m_{\ell} = +1$, $m_{s} = +\frac{1}{2}$

Element	12 ^A	11B
First ionization potential (k.J/mol)	+732	+495
Second ionization potential (kJ/mol)	+1451	+4558

The second ionization potential of element (B) is much higher than the second ionization potential of element (A), this is attributed to

- a losing 2 electrons from the principal level L in (B).
- The breaking the principal level L in (B) and the increase of the positive charge.
- breaking the principal level L in (A) and the increase of the positive charge.
- (1) losing 2 electrons from the principal level M in (A).
- 4 elements are located in one group starting from the second period in the periodic table, so the electron affinity of the element whose electron configuration is $1s^2$, $2s^2$, $2p^6$, $3s^1$ equals

@ -53 kJ/mol

(b) -60 kJ/mol

○ -48 kJ/mol

(d) -47 kJ/mol

The opposite table shows the electronic configurations of some elements, the element which has the highest electronegativity is

	3/
(R)	·Y
1-1	

© R

(d) Z

Element	Electro /	figuration
Х	[₁₀ Ne]:	$3s^2$, $3p^5$
Υ	[₁₀ Ne]:	$3s^2$, $3p^2$
Z	[₁₈ Ar]: 4s ²	$,3d^{10},4p^{5}$
R	[₃₆ Kr]: 5s ²	$,4d^{10},5p^{5}$

Quantum numbers

 $n = 3, l = 0, m_l = 0, m_s = +\frac{1}{2}$

 $n = 2, l = 1, m_l = +1, m_s = -\frac{1}{2}$

 $n = 2, l = 1, m_l = -1, m_s = -\frac{1}{2}$

n = 3, l = 0, $m_l = 0$, $m_s = -\frac{1}{2}$

Element

X

Υ

Z

R

The opposite table shows
the quantum numbers of
the last electron in
the atoms of some elements.
Which of these elements is electronegative?

(a)	γ

- **b** Х
- © R
- (d) Z
- The ion X^{3+} electronic configuration ends with $6s^0$, $4f^{14}$, $5d^8$ This means that element (X) is located in the group

b 10

© 11

d 9

- The opposite table shows the outer electron configurations of some elements.

 Which of the following is correct?
 - (a) HC is more acidic, and (A) has the largest radius.
 - b HB is more acidic, and (C) has the largest radius.
 - © HC is more basic, and (B) has the smallest radius.
 - d HB is more basic, and (A) has the smallest radius.

Element	The outer electron configuration
A	4s ¹
В	<i>3p</i> ⁵
С	4p ⁵

15 4 elements in the same group their . dis are estimated in angstroms.

(
1.96	2.27	1.52	2,48

Which of the following is correct?

- (a) Element (C) has lower electron affinity than element (A).
- (b) Element (A) has lower electronegativity than element (B).
- (c) Element (D) has higher electronegativity than element (C).
- (d) Element (B) has higher ionization potential than element (D).
- Assisted by the opposite diagram which shows the values of the first ionization potentials of elements of the same group in the periodic table.

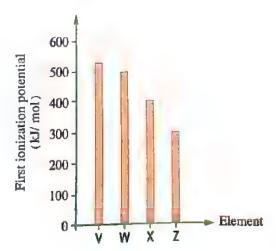
The element with the highest metallic property is



(b) **Z**

(c) V

(d) W



The opposite table shows the electronic configuration of the last sublevel in some elements.

Element	A	В	С	D
The electrons of the last sublevel	3p ^I	3p ⁵	3p ³	3p4

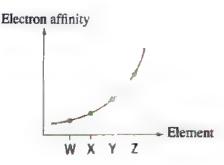
Which of the following is correct?

- (a) (B) is a nonmetal and its electron affinity is high.
- (b) (C) is a metal and its electron affinity is high.
- (c) (A) is a nonmetal and its electron affinity is low.
- (d) (D) is a metal and its electron affinity is low.
- According to the equation: $X + e^- \longrightarrow X^- + High energy$ Among the properties of element (X) that
 - (a) its oxide is amphoteric, and its ionization potential is high.
 - (b) its oxide is basic, and its ionization potential is high.
 - © its oxide is acidic, and its ionization potential is high.
 - (d) its oxide is acidic, and its ionization potential is low.

The opposite curve shows the graduation in the value of electron affinity of 4 elements in the third period (not in successive groups).

The correct order of the oxides of these

elements relative to the acidic property is



- (a) Z < Y < X < W
- (b) X < Y < Z < W
- \odot Z < W < X < Y
- \bigcirc W < X < Y < Z
- You have the element (X) which is a representative element, and their probable ionization potentials are :

•
$$X \longrightarrow X^+ + e^-$$
 , $\Delta H = +500 \text{ kJ/mol}$

•
$$X^+ \longrightarrow X^{+2} + e^-$$
, $\Delta H = + 675 \text{ kJ/mol}$

•
$$X^{+2} \longrightarrow X^{+3} + e^{-}$$
, $\Delta H = +8780 \text{ kJ/mol}$

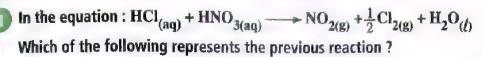
Then, the element which precedes it in the same period is located in

- (a) the first group A
- b the second group A
- © the fourth group A
- d the third group A
- Three representative elements X , Y and Z are located in one period and three different groups,

the formula of the oxide of each of them is : X_2O , YO_3 and ZO_2 The correct order according to the atomic radius of each of them is

- (1) Z > X > Y
- $\bigcirc X > Z > Y$
- $\bigcirc X > Y > Z$
- \bigcirc Z>Y>X

Choose the correct answer for the following questions:



- (a) Nitrogen undergoes oxidation process.
- (h) HNO, is the reducing agent.
- © Chlorine undergoes reduction process.
- d HCl is the reducing agent.

In the equation :
$$2\text{FeCl}_{3(aq)} + \text{H}_2\text{S}_{(aq)} \longrightarrow 2\text{HCl}_{(aq)} + 2\text{FeCl}_{2(aq)} + \text{S}_{(s)}$$

Which of the following represents the previous reaction ?

- (a) FeCl₃ is the oxidizing agent.
- (b) A reduction process occurs to sulphur.
- (c) H₂S is the oxidizing agent.
- d An oxidation process occurs to iron.
- Three different elements, their radii are ordered as follows: X > Z > Y, these elements form the following acids: HXO, H_4YO_4 , H_2ZO_2 What is the correct ascending order of the strengths of these acids?
 - \bigcirc H₄YO₄ < H₂ZO₂ < HXO
- \bigcirc H₂ZO₂ < H₄YO₄ < HXO
- \bigcirc H₂ZO₂ < HXO < H₄YO₄
- (d) $HXO < H_2ZO_2 < H_4YO_4$
- In the compound $C(OH)_4$, the attraction between (O,C) is equal to the attraction between (O,H), so this compound is ionized
 - (a) in water as a salt.

- (b) according to the type of the medium.
- in basic medium as a base.
- (d) in acidic medium as an acid.

n helium atom 2He,

- (a) the values of the spin quantum number are similar.
- (b) $m_1 = 1$
- the values of the spin quantum number are different.
- $\mathfrak{D} m_{\prime} = -1$

207

The electronic configuration of the element (X) ends as follows: ns^{l} , $(n-1)d^{5}$, and its electrons are distributed in 5 principal levels.

What is the atomic number of this element?

(a) 29

(b) 24

© 47

- d) 42
- Sr element is located in the fifth period, group (2A) in the modern periodic table.

 Which of the following represents the electronic configuration of its ion?
 - (a) [Ar], $4s^2$, $3d^{10}$, $4p^6$

(b) [Ar] $,4s^2$

© [Kr], $5s^2$, $4d^{10}$, $5p^4$

- (d) [Kr], $5s^2$
- In terms of the opposite table, if the length of the bond (C – Br) in $CBr_a = 1.91 \text{ Å}$

Bond	F-F	Br - Br
Bond length	1.28Å	2.28 Å

What is the length of the bond in CF_A ?

(2) 1.14 Å

(b) 1.41 Å

(c) 0.77 Å

- (d) 0.64 Å
- 9 Four ions : 19 M+, 4Z²⁺, 12Y²⁺, 37X⁺

What is the correct ascending order of their atomic radii?

 \bigcirc Z < Y < X < M

(b) Y < Z < M < X

 \bigcirc X < M < Y < Z

- \bigcirc Z < Y < M < X
- Which of the following choices is correct for the elements 19X and 17Y?
 - (a) It is easier to reduce (X) than (Y).
- (b) It is easier to oxidize (Y) than (X).
- © Both (X) and (Y) can be easily reduced.
- d It is easier to oxidize (X) than (Y).
- The opposite table shows some properties of the elements (X) and (Y) which are located in the second period in the periodic table. Which of the following statements is correct?

Property	(X)	(Y)
Electron affinity	Low	High
Ionization potential	Low	High
Oxidation number	+3	-2

- (a) Element (Y) is located in group (6A).
- (b) Element (X) is located in group (2A).
- © Element (X) is located in group (6A).
- d Element (Y) is located in group (2A).

12	The element whose last principal ene	rgy level $(n=3)$	contain	ıs 6 elec	trons fo	rms
	an amphoteric oxide.	🕒 an acid	dic oxide	2.		
	© a neutral oxide.	d a basic	oxide.			
13	The highest amount of energy is relea	sed when the e	xcited e	lectron (of hydro	gen
	atom transfers from					
	(a) the orbit M to the orbit L, and the lo	cation of this ele	ectron ca	n be det	ermined	
	(b) the orbit N to the orbit M, and neither	er the location n	or the sp	eed of th	is electr	on
	can be determined precisely.					
	© the orbit L to the orbit K, and this el	ectron has a dua	l nature.			
	d the orbit L to the orbit K, and both to	he location and t	he speed	of this	electron	
	can be determined precisely.					
14	Element (X) is located in the group (4.	A).				
	Which of the following its electron af	finity is the high	est?			
	(a) X ⁻ (b) X	© X ⁺		d >	(2-	
15	On comparing the properties of the el	lements of the g	roup wi	nose ele	ctronic	
	configuration ends with ns^I to the pro-					
	noticed that					
1	(a) their oxides are basic and their elect	ron affinities are	high.			
	b their oxides are acidic and their elec	tron affinities are	e low.			
	their oxides are basic and their elect					
	their oxides are amphoteric and their			igh.		
3	What are the values of both principal	and magnetic q	uantum	number	s of	
1	the penultimate electron in sodium at	om ²³ Na ?				
	ⓐ $n = 3$, $m_l = +2$	(b) $n = 3$, m _l = -	-1		
(© $n=2$, $m_{\ell}=+1$	\bigcirc n = 2	, $m_{\ell} = -$	-2		
) 1	he opposite table shows	Element	A	В	С	D
t	he radii of four different atoms.	Atomic radius	1.34 Å	2.11 Å	0.73 Å	1.74 Å
V	Which element among these elements	Atomic radios	1071			
ħ	as the highest electronegativity?					
(A	(b) B				
(C	(d) D				

The weakest metal in the group (IIA)	in the periodic table is located in
the	
(a) sixth period.	(b) fifth period.
© seventh period.	(d) second period.
What is the type of the elements in w	hich the electron configuration ends with
$ns^{1:2}$, $np^{1:5}$?	
(a) Representative.	(b) Main transition.
© Inner transition.	d Noble.
In the equation : MOH MO	+ H ⁺
If the values presented in the following	ing choices represent the first ionization
potentials of the first four elements i	in the same period «with no particular order
What is the value of the first ionization	on potential of (M) ?
(a) +580 kJ/mol	(b) +1400 kJ/mol
© +780 kJ/mol	d) +520 kJ/mol
The probability of the presence of the	e electron around the nucleus is represented
by	
(a) the orbital and the electron cloud.	
b the quantum and the line spectrum.	
© the line spectrum and the orbital.	
d the quantum and the electron cloud	i.
Dalton and Thomson agreed on that	carbon atom
a has no spaces within it.	(b) is electrically neutral.
© contains negative electrons.	d is a homogenous sphere.
The modern atomic theory agrees wi	ith Rutherford's atomic model on
(a) that the atom is not solid.	
b) that the electrons have wave prope	erties.
(C) that it is impossible to determine b	ooth the location and the speed of the electron
together precisely.	
d) the system of the revolving of the	electrons around the pucleus

the ionization potentials of three metals in the same period in the modern periodic table.

What is the proper graduation of

the metallic character of these elements?

notwial kj/mil)	2800	1500	700
	7,	51	47,

(a) B < C < A

(b) A < C < B

(C) C < B < A

 \bigcirc A < B < C

Three elements X, Y and Z, their electronic configurations end with ns^I .

and the values of their electron affinities are ordered as follows: Z > Y > XWhat is the correct order of graduation of their metallic character?

 $\bigcirc Y < Z < X$

(b) Z < X < Y

(c) Y < X < Z

 \bigcirc Z < Y < X

According to Hund's rule and Pauli's exclusion principle, the last two electrons which have the highest energy in the atom of the element ₂₆X are different in both quantum numbers

al and me

(b) n and my

© m_e and ℓ

(d) m_s and m_l

Bohr's atomic model differs from that of Rutherford.

What is the postulate in Bohr's model which clarifies this difference?

- The electron displays a line spectrum when it loses a quantum.
- The electron is a negatively charged material particle.
- The electron does not display a line spectrum when it loses a quantum.
- The electron revolves around the nucleus in certain orbits.

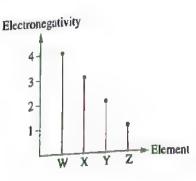
In the opposite graphical figure :
Which of these elements has lower electron affinity ?

3X

(b) Y

© Z

(1) W



(29	What is the symbol of the energy level which contains s , p and d		
	sublevels only ?		
	a L	ⓑ M	
	© N	(d) K	
(30	The first ionization potential of fluorine ($_9$ F) is higher than that of oxygen ($_8$ O)		
	because		
	a number of energy levels in fluorine > number of energy levels in oxygen.		
	(b) number of energy levels in fluorine < number of energy levels in oxygen.		
	© atomic radius of fluorine > atomic radius of oxygen.		
	d atomic radius of fluorine < a	atomic radius of oxygen.	
(31	What happens when sodium h	ydroxide solution is added to aluminum hydroxide ?	
	a They don't react together, because they are both acids.		
	(b) Al(OH) ₃ reacts as a base.		
	© They don't react together, because they are both bases.		
	d Al(OH)3 reacts as an acid.		
(32)	The electronic configuration of the ion of a trivalent metal is [Ar].		
1	What is the type of this metal?		
	(a) Main transition.	(b) Inner transition.	
	© Inert.	d Representative.	
(33)	Which of the following staten	nents represents the ionic compound which has	
1	the formula Y ₂ X ?		
	(Y) is a nonmetal, (X) is a metal.		
	(b) (Y) is a nonmetal, (X) is a metalloid.		
	© (Y) is located in group (1A), (X) is located in group (6A).		
	(d) (Y) is located in group (6A).	,(X) is located in group (1A).	
34	If the ions A ²⁺ , B ²⁻ are of two	elements in the same period.	
	Which of the following choices represents a comparison between		
	the electronegativities of the two elements of these ions ?		
	(a) A < B	(b) A ≥ B	
.6	© A > B	\bigcirc A = B	
7.6			

What is the sublevel in which the last electron has the two quantum				
numbers $(n=2, \ell=0)$?	numbers $(n=2, \ell=0)$?			
② 2s	$\bigcirc 2p$			
© 1s	(d) 3p			
The orbitals of the same sublevel are different in				
(a) the distance from the nucleus.	(b) the magnetic quantum number.			
© shape and size.	d the subsidiary quantum number.			
What is the number of orbitals o	What is the number of orbitals occupied by electrons in an atom in which			
3p sublevel is half filled with elec	3p sublevel is half filled with electrons?			
a 6	b 7			
© 8	(d) 9			
33 When an electron transfers from	When an electron transfers from the level K to the level L, it gains one quantum, and when it transfers from K to N, it gains			
and when it transfers from K to				
a 0.5 quantum.	b 1 quantum.			
© 2 quanta.	d 3 quanta.			
Among Heisenberg's modification	ns of Bohr's atomic model			
(a) it is difficult to determine both	 it is difficult to determine both the location and the speed of the electron together around the nucleus precisely. the space regions between energy levels are not forbidden for the electrons. the electron is a material particle with wave properties. 			
around the nucleus precisely.				
(b) the space regions between energing				
© the electron is a material particl				
1 both the location and the speed of the electron can be determined precisely.				
V.				

Guiding model

of Ministry of Education

Answered

Choose the correct answer for the following questions:

The opposite table shows the atomic radii of four elements in the same group in the periodic table estimated in angstroms.

Element	(A)	(B)		(D)
Atomic radius (Å)	1.96	2.27	1.52	2.48

Which of the following is correct?

- (a) Element (A) has lower electronegativity than that of element (B).
- (b) Element (D) has higher electronegativity than that of element (C).
- © Element (C) has lower electron affinity than that of element (A).
- d Element (B) has higher ionization potential than that of element (D).
- Bohr's atomic model is distinct from that of Rutherford in that the electrons in Bohr's model
 - (a) revolve in certain orbitals.
- (b) revolve in definite constant energy levels.

© revolve in high speed.

- d revolve around the nucleus.
- - (a) lose an amount of energy equals 1.89 eV (b) gain an amount of energy equals 1.89 eV
 - © lose an amount of energy equals 10.2 eV @ gain an amount of energy equals 10.2 eV
- The second and third ionization potentials of the element (X) are represented by the following equations:

$$X_{(g)}^{+} \longrightarrow X_{(g)}^{2+} + e^{-}$$

$$\Delta H = +1450 \text{ kJ/mol}$$

$$X_{(g)}^{2+} \longrightarrow X_{(g)}^{3+} + e^{-}$$

$$\Delta H = +7730 \text{ kJ/mol}$$

It is concluded from these two equations that the element (X) compared to the element which precedes it in the same period is

- (a) a nonmetal with lower ionization potential
- (b) a nonmetal with higher ionization potential
- © a metal with lower ionization potential
- d a metal with higher ionization potential

Two elements (X) and (Y) are located in the same period, their radii are (0.157 3) and (1.04 Å).

It is possible when they combine chemically that

- (a) element (X) undergoes oxidation and element (Y) undergoes reduction.
- (b) element (X) and element (Y) both undergo oxidation.
- (c) element (X) undergoes reduction and element (Y) undergoes oxidation.
- (d) neither element (X) nor element (Y) undergoes reduction.
- What is the drawback of Bohr's model which was modified by the modern atomic theory ?
 - (a) The electron has wave nature only.
 - (b) The electron is just a negatively charged particle.
 - (c) The electron has dual nature.
 - (d) The electron revolves around the nucleus in an electron cloud.
- The opposite table shows the electronic configurations of the atoms and ions of some elements.

 Which of the following choices represents the correct graduation of the electronegativities of these elements?

Atom or ion	Electronic
Atom of lon	configuration
A ¹⁻	[Ne]
B ² -	[Ne]
С	[Ar], 4s ¹
D	[Ne], 3s ¹

- $\bigcirc A > B > D > C$
- (b) B > C > A > D
- $\bigcirc D > C > B > A$
- $\bigcirc A > D > C > B$
- Each of hydrogen and helium contains one energy level.

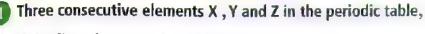
Which of the following describes the two elements?

- (a) The two elements are different in their line spectra.
- (b) The two elements are equal in the number of electrons in each of them.
- © The two elements are different in the principal quantum number of their valence electrons.
- d The two elements are similar in their line spectra.

- $oldsymbol{9}$ By applying the wave mechanical equation to the last electron in \cos am atom $_{11}N_{21}$ It is found that a) it is possible to determine its location precisely in the energy level M (b) it moves back and forth from the nucleus within the energy level [v] © its energy is lower than that of the electrons of the energy level L d) it transfers to the energy level L after losing a quantum. 10 To obtain the hydrogen atom visible spectrum of an electron which has been excited
- to the third energy level M, this electron must
 - (a) lose a quantum lower than that gained.
 - (b) lose a quantum which is gained.
 - (c) gain a quantum.
 - d lose a quantum higher than that gained.
- 111 The electronic configuration of the element (X) ends with $3p^I$ sublevel. Which of the following choices represents the element (X) relative to the elements which precede it in the same period?
 - (a) A nonmetal with high electron affinity.
 - (b) A nonmetal with low electron affinity.
 - © A metal with high electron affinity.
 - (d) A metal with low electron affinity.
- 12 The electron configuration of element (X) ends with the sublevels : $5s^2$, $4d^{10}$, $5p^5$ Which of the following choices represents the element (X) relative to the elements which precede it in the same period?
 - (a) Its oxide is basic and its ionization potential is small.
 - (b) Its oxide is amphoteric and its ionization potential is high.
 - © Its oxide is acidic and its ionization potential is high.
 - d Its oxide is acidic and its ionization potential is small.

Choose the correct answer for the questions (2):





if the first element X is a noble gas.

What is the symbol of the ion of Z?

(a) Z^{2-}

(b) Z²⁺

(c) Z

Here are 4 hypothetical symbols for four elements ions : $(A^{2+}/B^-/C^+/D^{2+})$. Which of the following statements represents all these ions?

- (a) The number of electrons in each of them is higher than that of the protons.
- (b) Their nuclei contain the same number of neutrons.
- (c) Their nuclei contain the same number of protons.
- (d) The electronic configuration of each of them is similar to that of the nearest inert gas.
- 3 Element (X) burns in air forming white powder which when dissolved in water, it forms a solution turns the red litmus paper into blue.

What is the probable name of this element?

(a) Sulphur.

(b) lodine.

© Carbon.

(d) Magnesium.

In which of the following ions the electron cloud has the largest size?

(a) S²⁻

(b) Al³⁺

© Be²⁺

(d) N^{3-}

What is the number of electrons lost or gained by nitrogen atom in this conversion: $NO_2 \longrightarrow N_2O_3$?

(a) It loses one electron.

(b) It loses two electrons.

© It gains one electron.

d It gains two electrons.

- 6 Which of the following is incompatible with aufbau principle?
 - a 1 111

6 4 4 4

0 1 111

- @ **# | | |**
- Which of the following represents both the location and the block of the element whose atomic number is 24?

Choices	Period	Group	Block
(a)	6	4B	d
	4	6B	d
0	6	4B	p
(d)	4	6B	P

- 8 What is the number of the elements which may form compounds but with great difficulty in the fourth period in the periodic table ?
 - (a) 1
- (b) 2
- © 3
- (d) 4
- What is the number of the elements in which the orbitals of 4d sublevel contain one single (unpaired) electron or more in the ground state ?
 - a 7

(b) 8

© **9**

- (d) 10
- Which of the following choices represents the electronic configuration of the atom which has higher electron affinity?
 - (a) [Ne], $3s^2$, $3p^5$

- (b) [Ne], $3s^2$, $3p^2$
- © [Ne], $3s^2$, $3p^6$, $3d^5$, $4s^1$
- (d) [Ne], $3s^2$, $3p^4$
- Which of the following elements has the highest electronegativity?
 - (a) 13Al

ы

© 16S

- (d) 34Se
- Which of the following elements has the lowest first ionization energy?
 - $\bigcirc 3_5B$

⊕ 6C

© 13AI

d ₁₄Si

Which choice does represent the correct graduation in increasing the metallic property?

(a)
$$_{14}Si < _{15}P < _{16}S$$

$$\bigcirc_{33}$$
As < $_{15}$ P < $_{7}$ N

$$\bigcirc$$
 ₁₃Al < ₃₂Ge < ₅₁Sb

①
$$_{35}$$
Br < $_{34}$ Se < $_{33}$ As

- Two ions (X⁻) and (Y⁺), both have the same electron configuration [Ar].

 Which of the following statements represents the two elements of these ions?
 - (a) The atomic radius of element (X) equals half that of element (Y).
 - (b) The electronegativity of element (X) equals that of element (Y).
 - © The first ionization potential of element (X) is lower than that of element (Y).
 - (d) The electron affinity of element (Y) is lower than that of element (X).
- Which of the following transitions in an atom of hydrogen produces a photon with the highest energy?

(a)
$$(n = 3) \longrightarrow (n = 1)$$

(b)
$$(n = 5) \longrightarrow (n = 3)$$

(c)
$$(n = 12) \longrightarrow (n = 10)$$

(d)
$$(n = 22) \longrightarrow (n = 20)$$

Which of the following represents an electron configuration of an excited atom ?

(a)
$$1s^2$$
, $2s^2$, $2p^1$

$$\textcircled{b}$$
 $1s^2$, $2s^2$, $2p^2$

©
$$1s^2$$
, $2s^2$, $2p^2$, $3s^1$

$$\textcircled{1}$$
 $1s^2$, $2s^2$, $2p^5$

In the reaction: $ClO_3^- + 5Cl^- + 6H^+ \longrightarrow 3Cl_2 + 3H_2O$

What are the oxidizing and the reducing agents?

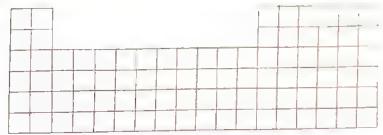
Choices	Oxidizing agent	Reducing agent
(a)	CI	CIO ₃
Ь	ClO ₃	Cl
0	ClO ₃	Н ⁺
(1)	CI	H ⁺

18	Which of the following eleme	ents atoms in its ground state could have an electron				
	with the quantum numbers :	$(n=3, \ell=2, m_{\ell}=0, m_{s}=+\frac{1}{2})$?				
	a ₁₁ Na	(b) ₁₂ Mg				
	© 15P	(d) ₂₃ V				
19		ely with 16 g of oxygen gas to form 22 g of ${ m CO}_2$				
	What is the mass of ${\rm CO_2}$ wh	nich is produced from a mixture formed 이 34 g				
	of carbon with 100 g of oxyg	gen gas ?				
	(a) 40 g	(b) 44 g				
	© 88 g	(d) 112 g				
20	All the following are deflect	ted by the effect of the charged plates, except				
	a hydrogen atoms.					
	(b) cathode rays.					
	© alpha particles.					
	d protons.					
21	What is the name of the hal	logen which is located in the third period in				
	the periodic table ?					
	(a) Chlorine 17Cl					
	(b) Iodine ₅₃ I					
	© Bromine 35Br					
	d Astatine 85At					
1						
22		e oxidation number of the representative element whose last				
	electron has the quantum nur	mbers: $(l = 0, m_g = -\frac{1}{2})$.				

	** ************************************					
		······································				

			3	
the same atom. Which of them has	Electron	6	0	0
	***************************************	110107 11		

The following figure represents a section in the periodic table :

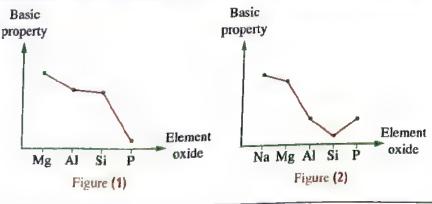


 Calculate the difference between the number of the elements of s-block and the number of the elements of p-block.

(2) What is the missing block in this table?

2 marks

Which of the following graphical figures represents the graduation of the basic property of the oxides of the elements of the third period in the periodic table?



1 mark

221

26	What is the number of each of the completely filled orbitals and the parrially occur	ıpied
	by electrons in the gaseous state of the atom of vanadium element 23V	
	in its ground state?	

1		

Complete the four quantum numbers of the last electron in the element (Y), knowing that it follows the element (X) in the same period in the periodic table:

Quantum numbers	(n)	(1)	(m _ℓ)	(m _s)
The element (X)	3	2	+2	$-\frac{1}{2}$
The element (Y)	*****	4 1 14 1 10 4 4	*****	,,,,,,,,,



Exam model

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Answered

· Choose the correct	t answer for the at	research Res				
What is the number	r of the inner trans	sition elements in bot	h fourth and fifth po			
in the periodic tab	le?					
a Zero	b 14	© 24	d 28			
If aufbau principle	is disregarded in d	istributing the electro	ons of the elements.			
₂₀ Ca would be loca	ited in					
(a) s-block.	b p-block.	© d-block.	d f-block.			
What is the atomic	number of the ele	ment in which the orb	itals of 4p sublevel			
contain the highest	possible number o	of single electrons?				
② 23		(b) 26				
© 3 3		(d) 35				
	ing elements has t	the highest ionization	potential ?			
(a) Ne		(b) Не				
© Be		d Te				
In Rutherford's expe	eriment, upon shoo	oting a beam of				
a beta particles on gold foil, it is absorbed.						
ⓑ gamma rays on g	old foil, electrons a	re liberated from its su	rface.			
© helium atoms on gold foil, most of them are scattered.						
d helium nuclei on gold foil, some of them are scattered.						
Understanding the r	novement of the el	ectrons in the atom i	s based on			
all the following, ex						
(a) Rutherford's expe	riment which prove	ed the presence of the	nucleus.			
(b) Thomson's atomic						
© Bohr's model of a	tom which is based	on hydrogen atom.				
 Schrödinger's equ 	ation which introdu	red the concent of the	orbital.			

	1 215						
	alogen acid is	 (c) HF	(d) H(
(a) HBr	(p) HI	•	0				
			d by electrons \dots the atom				
of the element	s located in the sixth	period in the periodi	ic table, where the electron				
has the quantu	im number ($m_{\ell} = +3$)	?					
(a) 1	(b) 3	© 5	d 7				
One of the stud	dents presumed wron	gly that the two elec	trons (X) and (Y) which are				
in the same at	om have the followin	g quant <mark>um num</mark> bers :					
• Electron (X) :	$m=4$, $\ell=0$, $m_{\ell}=$	$0 \ , \ \mathbf{m}_{s} = +\frac{1}{2}$					
• Electron (Y) :	$n=4$, $\ell=0$, $m_{\ell}=$	$0, m_s = +\frac{1}{2}$					
What is the ru	What is the rule or the principle which explains this mistake ?						
a Pauli's excl	usion principle.	(b) Aufbau pr	rinciple.				
© Hund's rule) Pd	d Uncertain	ty principle.				
Which of the f	ollowing equations re	epresents the electro	n affinity of				
bromine?							
(a) Br _(g) →	$Br_{(g)}^+ + e^-$		—→ Br _(g)				
© $Br_{2(g)} + e^{-}$	— 2Br _(g)		$Br_{(g)}$				
Which of the f	ollowing loses electro	ons in the redox (oxid	ation-reduction) reactions				
(a) The substance which undergoes oxidation.							
ⓑ The cathode.							
© The oxidizi	© The oxidizing agent.						
d The atom o	r the ion whose oxida	tion number decreases	S.				
Which of the fo	ollowing is a correct a	application of one of	the postulates of				
Dalton's theor	y ?						
a The atoms	of a sample of iron are	not necessarily simil	lar.				
(b) Hydrogen s	substance is formed of	very minute particles	s called ions.				
© Water is for	rmed from hydrogen a	ind oxygen elements i	in a constant weight ratio.				

(d) Carbon and hydrogen elements combine in different weight ratios to form many

compounds.

(a) F

(c) 5

(b) Ne

(b) 3

(d) 7

© Na+

(a) Zero

(d) CI

Chlorite ion. Perchlorite io		
he oxidation number of manganese is +3 in	n 11 to too	(b) Hypochlorite ion.
$(m_1)^2 = (m_2)^2 = (m_2)^2 = (m_2)^2 = (m_3)^2 = (m_3)^2 = (m_3)^2 = (m_3)^2 = (m_4)^2 = (m_4$	Perchlorite ion.	(d) Perchlorate 10n.
Mn ₂ O ₃	oxidation number of manganes	e is +3 in
which of the following represents the quantum numbers of the farther om the nucleus in scandium atom $_{21}$ Sc? Explain. The first set: $(n = 3, \ell = 2, m_{\ell} = -2, m_{s} = +\frac{1}{2})$.	KMnO ₄	1 2
from the nucleus in scandium atom $_{21}$ Sc ? Explain. the first set : $(n = 3, \ell = 2, m_{\ell} = -2, m_{s} = +\frac{1}{2})$.	Mn_2O_3	(d) MnO
from the nucleus in scandium atom $_{21}$ Sc ? Explain. the first set : $(n = 3, \ell = 2, m_{\ell} = -2, m_{s} = +\frac{1}{2})$.	ch of the following represents t	the quantum numbers of the farthe
he first set: $(n = 3, \ell = 2, m_{\ell} = -2, m_{s} = +\frac{1}{2})$.		
he second set: $(\mathbf{n} = 4, t = 0, \mathbf{m}_t = 0, \mathbf{m}_s = -\frac{2}{2})$.		
	second set: $(n = 4, l = 0, m_l =$	$0, m_{\rm s} = -\frac{1}{2}$.
	vjabiphobviv++==================================	
	D+##F##+-**B#################################	

	following figure represents a	section in the periodic table :
	following figure represents a	section in the periodic table :
	following figure represents a	section in the periodic table :
	following figure represents a	section in the periodic table :

(1) What is the difference between the number of representative elements
and the number of the main transition elements?
(2) Shade the location of the element which lies in the fourth period, group (3A).

2 marks





The following table represents a section in the process to table:

A		. ' [
	В	E	1

What is the hypothetical symbol of the element which is characterized by that:

- (1) Its ion carries two positive charges.
- (2) Its electron configuration ends with : $4s^2$, $3d^6$



The compound ClO₂ is formed in industry from the reaction of NaClO₃ with HCl

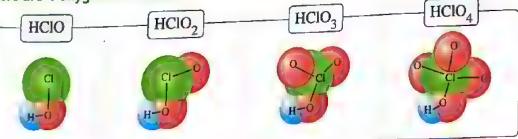
Which of the former three compounds is the compound in which the oxidation number of chlorine is the highest?



Write the balanced symbolic equation which represents the reaction of aluminum oxide with sulphuric acid.



27 Here are 4 oxygenated acids:



Which of these acids has the lowest (n) value ? What is this (n) value ?



Exam model 3

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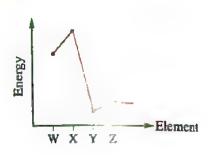
Choose the correct answer for the questions 11:21



The opposite figure represents the second ionization potentials of some elements.

Which of them represents 3Li?

- (a) W
- (b) X
- (c) Y
- (d)Z



Element Q is located in the group (6A) in the periodic table, its nucleus contains x number of neutrons and y number of protons.

Which of the following choices represents the ion of this element?

(a)
$$x + y_0^2 Q^{2+}$$

$$\bigcirc x + y_0^{2}$$

$$\left(d \right)_{y}^{x} Q^{2}$$

3 The oxidation number of carbon equal zero in

Which of the following is an electron configuration of a stable atom?

(a) [Ne],
$$3s^2$$
, $3p^3$, $4s^1$

(b)
$$1s^2$$
, $2s^2$, $2p^4$, $4s^2$

© [Ne],
$$3s^2$$
, $3p^6$, $4s^1$

$$\bigcirc$$
 1s^I, 2s^I

Which of Dalton's postulates is still valid up till now?

- (a) Atoms are minute particles.
- (b) Atom is indivisible.
- (c) Atoms of the same element have the same mass.
- (d) All the atoms of the same element are different in mass from the atoms of the other elements.

6 Which of these ions its electronic configuration is not similar to that of a noble gas?

Which of the following are the oxidation numbers of nitrogen and chlorine (respectively) in NOCIO₄ ?

 \bigcirc +2 and -7

 \bigcirc -3 and +5

 \bigcirc +2 and +7

(1) +3 and +7

Which of the following represents the correct graduation in the properties of the oxides of the elements of the third period ?

Choices	Na ₂ O	MgO	Al ₂ O ₃	SiO ₂	P ₂ O ₅	SO ₃	Cl ₂ O ₇
(1)	Basic	Basic	Amphoteric	Amphoteric	Amphoteric	Acidic	Acidic
Ъ	Basic	Basic	Amphoteric	Acidic	Acidic	Acidic	Acidic
0	Basic	Basic	Basic	Amphoteric	Acidic	Acidic	Acidic
(d)	Basic	Basic	Amphoteric	Amphoteric	Acidic	Acidic	Acidic

What are the quantum numbers (n), (ℓ) of the orbitals which are occupied successively by electrons in all lanthanides ?

(a) n = 4, l = 3

(b) n = 3, l = 4

© n = 4, l = 1

(d) n = 5, l = 2

10 Each of the following matches Pauli's exclusion principle, except

a 1 1

6 11 11 11

© 11 11 11 I

@ # # **1**

Which of the following oxygenated acids is stronger?

a HClO₂

b HNO2

© HIO3

(d) HBrO

Which of the following choices shows the charge and the location of the electron in the atom?

Choices	Charge	Present inside the nucleus
a	Negative	No
b	Negative	Yes
©	Positive	No
(1)	Positive	Yes

13 The line spectrum of sodium contains one coloured line, while the line spectrum of hydrogen contains 4 coloured lines.

What does this statement indicate?

- (a) Hydrogen molecule is formed of four atoms.
- (b) As the power of the spectroscope increases, the number of lines which can be seen increases.
- (c) There are four excited electrons in hydrogen atom.
- According to the modern atomic theory,
 - (a) the electron can not be found in the same place two successive times.
 - (b) the electrons need to absorb energy photons continuously to move to higher levels.
 - © the charge of the electron = 1.602×10^{-19} C
 - (d) it is impossible to determine the position and the velocity of the electron precisely at the same time.
- B Which of the following sets of quantum numbers is not possible?

(a)
$$n = 2$$
, $l = 0$, $m_l = +1$

(b)
$$n = 2$$
, $l = 1$, $m_l = +1$

©
$$n = 2$$
, $l = 0$, $m_l = 0$

(d)
$$n = 2$$
, $l = 1$, $m_j = -1$

Which of the following represents the electronic configuration of

manganese (III) ion?

(Mn atomic number = 25)

(a)
$$1s^2$$
, $2s^2$, $2p^6$, $3s^2$, $3p^6$, $3d^4$

ⓑ
$$1s^2$$
, $2s^2$, $2p^6$, $3s^2$, $3p^6$, $3d^5$, $4s^2$

©
$$1s^2$$
, $2s^2$, $2p^6$, $3s^2$, $3p^6$, $3d^2$, $4s^2$

(d)
$$1s^2$$
, $2s^2$, $2p^6$, $3s^2$, $3p^6$, $3d^6$, $4s^2$

- Which of the following is correct?
 - (a) The elements in the same group have the same number of electrons in the energy levels.
 - (b) The elements in the periodic table are ordered according to increasing the number of their protons.
 - © The metals are on the right and the nonmetals are on the left of the periodic table.
 - d) Active elements are located at the bottom of every group in the periodic table.

10	Which of the following groups its elements electronic configurations
	end with: ns^2 , np^1 ?
	() 1A (1), 2A
	○ 3A
(0	Which of the following chemical processes is impossible to occur?
	\bigcirc Ca _(g) + Energy \longrightarrow Ca ²⁺ _(g) + 2e
	\bigcirc H _{2(g)} + Energy \longrightarrow 2H ⁺ _(g) + 2e
0	Four different elements: 12A, 4B, 38C, 56D
	Why do these elements belong to the same group in the modern periodic table?
	Because they are all metals which can combine with oxygen forming oxides with
	a general formula MO
Ш	1 Because they are all nonmetals which can form ions with the symbol M ²
	Because they are all nonmetals whose valence shells contain 2 electrons.
п	\bigcirc Because they are all metals whose atoms electron configurations end with ns^2
0	Chlorine replaces iodide ion in potassium iodide solution according to
	the equation : $Cl_2 + 2I^- \longrightarrow I_2 + 2CI^-$
	What is the oxidizing agent in this reaction?
	Chloride ions.
	Chlorine gas.
	Jodide ions.
	C lodine vapours.
í	
P	The electron configuration of the element (X) ends with the sublevel 4s'
п	the product of ionization of XOII in water? Explain.
	2 marks
	231

contain protons, neutrons and e	
What is the effect of passing a	
between the two electrodes of a	
in the opposite figure? Explain	Electron curren

	h period in the periodic table be similar in containing
	If filled with 5 unpaired electrons?
Explain your answer.	

Study the scheme, then answ	rer:
Study the scheme, then answ $Mg + O_2$	/er:
	(X)····
Mg + O ₂	(X)····
	(X)····
Mg + O_2 SO_3 + H_2O	(X)
Mg + O_2 SO_3 + H_2O (1) Write the chemical formula	a of the two compounds (X) and (Y).
Mg + O_2 SO_3 + H_2O (1) Write the chemical formula (X):	a of the two compounds (X) and (Y).
Mg + O_2 SO_3 + H_2O (1) Write the chemical formula	a of the two compounds (X) and (Y).
Mg + O_2 SO_3 + H_2O (1) Write the chemical formula (X): (Y):	a of the two compounds (X) and (Y).
Mg + O_2 SO_3 + H_2O (1) Write the chemical formula (X): (Y):	a of the two compounds (X) and (Y).
Mg + O_2 SO_3 + H_2O (1) Write the chemical formula (X): (Y): (2) Write the symbolic equation	a of the two compounds (X) and (Y).



The opposite table shows the four quantum numbers of the last electron in the atom of each of the element (X) and the element (Y).

Una dum numbers	(n)	(b)	(m _l)	(£g r)
Committee	2	1	0	+ 1/2
Element (Y)	6	1	0	+ 1/2

Which of the two elements when its pure vapours are exposed to low pressure in a discharge tube, its last electron becomes excited, and acquires the same quantum numbers of the other element? Explain.

1	
	1 mark

The opposite table illustrates the radii of some atoms and ions.

Н	Cl	Na	Na ⁺	CI
0.3 Å	0.99 Å	1.57 Å	0.95 Å	1.81 Å

Calculate the bond length in each of :

(1) Hydrogen chloride molecule.

(2) Sodium chloride formula unit.



Exam model 🚣



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Choose the correct answer for the questions 1 : 21 The term electron was not known at the time of formulating (b) Bohr's atomic model. (a) Rutherford's atomic model.

© Thomson's atomic model. If the principal quantum number of the last electron in the atom of a noble gas is (n = 3).

What is the number of the orbitals which are completely filled with electrons in this atom?

(a) 3

(b) 5

© 7

(d) Bohr's modified atomic model.

What is the number of the unpaired (single) electrons in the atom of phosphorus , P?

(a) 1

(b) 2

© 3

(d)4

Bromine is similar to chlorine in all the following, except that

(a) they are located in the same block in the periodic table.

(b) they have the same oxidation numbers.

(c) they are located in the same group.

(d) they are located in the same period.

S What is (are) the type(s) of the two elements whose ions form iron (II) sulphide?

(a) Main transition metal and representative nonmetal.

(b) Representative metal and representative nonmetal.

(c) Inner transition metal and metalloid.

(d) Both are representative metals.

What is the correct descending order of the electron affinities of carbon, oxygen, fluorine and chlorine?

(a) CI>F>O>C

(b) 0 > C > F > C

(c) F>C>O>Cl

(d) C > O > Cl > F

Which of the following pairs of atomic numbers belongs to two elements which are located in the same block and the same period in the modern periodic table?

(a) 41,74

(b) 8, 36

© 64,68

(d) 12,72



- Which of the following electronic configurations belongs to an atom of an element which the difference between its third and second ionization potentials is very high?
 - (a) $1s^2$, $2s^2$, $2p^6$, $3s^1$

$$\bigcirc 1s^2, 2s^2, 2p^6, 3s^2, 3p^1$$

 $\bigcirc 1s^2, 2s^2, 2p^6, 3s^2, 3p^2$

- When MnO₄ is converted to Mn²⁺, this is described as
 - (a) a reduction process, because the oxidation number of Mn increases.
 - (b) an oxidation process, because the oxidation number of Mn increases.
 - (c) a reduction process, because the oxidation number of Mn decreases.
 - (d) an oxidation process, because the oxidation number of Mn decreases.
- Mhich of the following oxides is the most basic oxide?
 - (a) Al₂O₃
- ⓑ K₂O
- @ CO,
- (I) MgO
- - (a) $ns \longrightarrow (n-2)f \longrightarrow (n-1)d \longrightarrow np$
 - (b) $ns \longrightarrow (n-1)d \longrightarrow (n-2)f \longrightarrow np$
 - \bigcirc ns \longrightarrow (n-2)f \longrightarrow np \longrightarrow (n-1)d
 - (d) $ns \longrightarrow np \longrightarrow (n-1)d \longrightarrow (n-2)f$
- Which of the following can not be explained by Dalton's model of the atom?
 - (a) The law of constant proportion.
 - (b) The difference between the element and the compound.
 - © The difference between the isotopes of the same element.
 - d The difference in the atomic masses of the elements.
- When the last electron in sodium atom is excited to the energy level (n = 5), it
 - ⓐ remains in the energy level (n = 5).
 - \bigcirc returns to the energy level (n = 3) in one jump.
 - © returns to the energy level (n = 4) then to (n = 2).
 - (d) returns to the energy level (n = 2).
- Each of the following sets of quantum numbers is possible, except

Choices	(n)	(1)	(\mathbf{m}_{ℓ})	(m _s)
(a)	3	1	-1	0
b	3	2	+2	$-\frac{1}{2}$
0	4	3	+2	$-\frac{1}{2}$
d	5	3	+2	$+\frac{1}{2}$

What is the correct electron configuration of magnesium ion Mg^{2+} in the excited state?

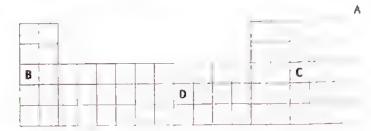
(a) $1s^2$, $2s^2$, $2p^5$, $3s^2$

(b) $1s^2$, $2s^2$, $2p^6$, $3s^1$

(c) $1s^2$, $2s^2$, $2p^6$

(d) $1s^2$, $2s^2$, $2p^5$, $3s^1$

The following table represents a section in the periodic table :



Which of the following describes one of these elements?

- (a) Element A ends with the electronic configuration: ns^2 , np^6
- (b) Element B has more than one oxidation number.
- © Element C is a metalloid.
- (d) Element D is an inner transition element.

17 Each of the following describes the element ₁₇M, except that

- (a) it is an electronegative nonmetal.
- (b) it forms M⁺ which contains 4 unpaired electrons.
- © its oxidation numbers range between -1 to +7
- (d) it forms acidic oxides such as: M2O3 and M2O5

What is the atomic number of the element which is located in the sixth period in the periodic table and it is an alkali earth metal?

(a) 56

b 55

© 87

(d) 88

The opposite table shows the types of the oxides of four elements which belong to the same group.

What is the letter which refers to the element with the lowest electronegativity?

(a) R

(b) Q

© P

(d) S

Element	Type of its oxide
P	Acidic
Q	Amphoteric
R	Amphoteric
S	Basic

(a) HBrO is the weakest acid among the	of these ac						
(b) Oxidation number of bromine in HBrO ₃ equals (-1).							
© HBrO ₂ is the strongest acid among the	44						
(d) The ratio (n : m) in HBrO equals (1 :							
		W O					
In the reaction: $Sb_2O_3 + 6H^+ + 6e^-$							
What is the change in the oxidation nu		decreases	hy 3				
(a) It increases by 3		decreases					
© It increases by 6		decreases.					
The opposite table shows			- stanti:	ol (k I/mei	h		
the ionization potentials (first to fifth)			Third	fourth	Fif		
of one of the elements of the third	First	Second					
period in the modern periodic table.	+577.9	+1820	+2750	+11600	414		
Deduce the electron configuration							
of this element and calculate its atomic	number.						
	*************	**********					
					4.5		
					1		
The last electron in the atom of an elemen	at has the G	ua ntum n i	imbers :				
The last electron in the atom of an elemen	m = -1 1	$n = -\frac{1}{2}$					
$(n=3, \ell=1)$	III file heli	Juic table					
(n = 3, l = 1). Determine the location of this element				******			
		<pre><pre><pre></pre></pre></pre>					
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					-{		

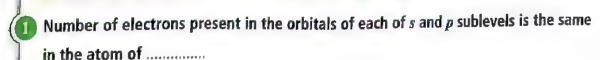
237

	H										[1	
	Li											В	С		0	F		
	Na	Mg										Al		P	S	Cl	Ar	
		Ca			V			Fe		Cu	Zn							
Answer	the f	ollo	win	a :														
(1) What					f tha		nine	ad al	ectron	e in t	he id	on o	f M	g ?				
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(2) Circl										getne	r 10 l	IOIII	ıac	UIIIJ	נשטק	III.	1	
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If you lo	DOM:	thet	the	hor	n lov													
																		2
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in hydro	gen	mole	cul	e H	equ	als	0.6	Å, v	vhile i									Å
in hydro	gen	mole	cul	e H	equ	als	0.6	Å, v	vhile i	n wat								Å
in hydro	gen	mole	cul	e H	equ	als	0.6	Å, v	vhile in ule.	n wat								Å
in hydro	gen	mole	cul	e H	equ	als	0.6	Å, v	vhile in ule.	n wat								Å
in hydro	gen	mole	cul	e H	equ	als	0.6	Å, v	vhile in ule.	n wat								Å
in hydro	gen	mole	cul	e H	equ	als	0.6	Å, v	vhile in ule.	n wat								Å
in hydro	gen	mole	cul	e H	equ	als	0.6	Å, v	vhile in ule.	n wat								Å
in hydro	gen	mole	cul	e H	equ	als	0.6	Å, v	vhile in ule.	n wat								Å
in hydro	gen	mole	cul	e H	equ	als	0.6	Å, v	vhile in ule.	n wat								Å
in hydro	gen	mole	cul	e H	equ	als	0.6	Å, v	vhile in ule.	n wat								Å
If you ki in hydro Calculat	gen	mole	cul	e H	equ	als	0.6	Å, v	vhile in ule.	n wat								Å
in hydro	gen	mole	cul	e H	equ	als	0.6	Å, v	vhile in ule.	n wat								Å
in hydro	gen	mole	cul	e H	equ	als	0.6	Å, v	vhile in ule.	n wat								Å
in hydro	gen	mole	cul	e H	equ	als	0.6	Å, v	vhile in ule.	n wat								Å
in hydro	gen	mole	cul	e H	equ	als	0.6	Å, v	vhile in ule.	n wat								Å
in hydro	gen i	mole e bor	ecul	e H.	, equ	uals (0.6 .) m	Å, w	vhile in	n wate	er m	olec	cule) eq	uals		Å
in hydro Calculat	gen i	mole e bor	ecule nd l	e H_ leng	, equ th ii	uals (O.6 m	Å, wolec	vhile in	n wate	er m	olec	cule) eq			Å
in hydro Calculat	gen i	mole e bor	ecule nd l	e H_ leng	, equ th ii	uals (O.6 m	Å, wolec	vhile in	n wate	er m	olec	cule) eq	uals 5		Å
in hydro Calculat	gen i	mole e bor	ecule nd l	e H_ leng	, equ th ii	uals (O.6 m	Å, wolec	vhile in	n wate	er m	olec	cule) eq	5 1	0.96	7
The opp	gen i	e figi	ure	sho	equeth in	als on NC	o.6 .	Å, wolec	the p	n wate	er m	olec	cule) eq	5 1	0.96	
in hydro Calculat	gen i	e figi	ure	sho	equeth in	als on NC	o.6 .	Å, wolec	the p	n wate	er m	olec	cule) eq	5 1	0.96	

Exam model 5

Open Book





(a) 7N

ы Nа

© ₁₂Mg

(d) ₁₄Si

The following are some postulates of the theories which explain the atomic structure :

• Theory (A): The electronic shells surround the nucleus which is in the center of the atom.

Theory (B): The atom is invisible solid sphere.

Theory (C): The atom contains vast space.

What is the historical order of these three theories?

 \bigcirc A \longrightarrow B \longrightarrow C

(b) B → C → A

 $\bigcirc A \longrightarrow C \longrightarrow B$

(d) B → A → C

(a) CsI

(b) CsF

© LiF

d NaF

All the following combinations of the quantum numbers are not allowed,

except

(a) n = 2, l = 2, $m_{\ell} = +1$

b $\mathbf{n}=2$, $\ell=-1$, $\mathbf{m}_{\ell}=0$

© n = 3, l = 2, $m_l = +3$

(d) n = 4, l = 3, $m_l = -2$

Which of the following electron configurations does not verify both Hund's rule and the exclusion principle together?

a 1 11 1

b 1 1 1

01111

1 1 1 1 1 1

6 In the opposite table.
What does (X) represent?

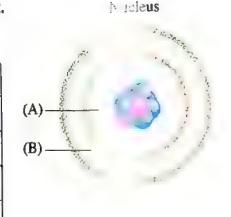
Element	LA	Бе	В	C	14		1	
Atomic number	3	4	5	6	7	8	9	
(x) values	1.28	1.91	2.42	3.14	3.83	4.45	5.10	

TI DO B C N O F

- (a) Ionization potential.
- (b) Electronegativity.
- © Effective nuclear charge.
- d Electron affinity.
- The opposite figure represents an atom of an element.

 Which of the following represents (A) and (B)?

Choices	(A)	(B)
(a)	Orbital	Orbital
Ъ	Electron cloud	Electron cloud
©	Electron cloud	Orbital
d	Orbital	Electron cloud



What is the correct order which represents the numbers of the single (unpaired) electrons in the ions of these transition elements?

(a)
$$Cu^{2+} > Ni^{2+} > Cr^{3+} > Fe^{3+}$$

(b)
$$Cr^{3+} > Fe^{2+} > Ni^{2+} > Cu^{2+}$$

©
$$Fe^{3+} > Cr^{3+} > Cu^{2+} > Ni^{2+}$$

(d)
$$Fe^{3+} > Cr^{3+} > Ni^{2+} > Cu^{2+}$$

Three acids which are: HClO, HBrO₄, HIO₃

Which choice represents a similarity and a difference between the

Which choice represents a similarity and a difference between these acids ?

Choices	The similarity	The difference
(a)	Oxidation number of the central atom	Oxidation number of O atom
ь	Their strengths as oxygenated acids	Their hydroxy formula
0	Oxidation number of the central atom	Number of oxygen atoms nonbinded to hydrogen
d	Oxygenated halogen acids	Their strengths as oxygenated acids

Which of the following represents the number of the natural noble gases in the periodic table?

Choices	In the same period	in group zero	In p-block	In the periodic table
(1)	1	6	0	6
Ъ	1	6	6	6
0	0	5	6	5
(d)	6	6	0	5

M	What are the two elements which have almost the same ionization p	otential?
---	---	-----------

- (a) ₁₃Al , ₃₁Ga (b) ₃₈Sr , ₃₁Ga

12 The periodic table includes the known elements arranged according to their(1)......, in the group (1A) the metallic property(2)...... from the top to the bottom, and in the group (7A) the electronegativity(3)....... from the bottom to the top.

Which of the following choices represents the numbers (1), (2) and (3) in the previous statement?

Choices	(1)	(2)	(3)
(a)	atomic numbers	increases	decreases
6	atomic numbers	increases	încreases
0	mass numbers	decreases	increases
(d)	mass numbers	increases	decreases

Chlorine has an oxidation number +5 in

- (a) NaClO
- (b) NaClO₂
- © NaClO₂
- (d) NaClO₄

4 How many unpaired electrons does a ground state $_{24}\mathrm{Cr}^{2+}$ ion have ?

- (a) (1)
- (b) 2

(c) 4

(d) 6

	this element ? (a) Acidic. (b) Basic.	© Neutral.	(i) Am	photeri	c.		
	What is the type of the oxide of							
	in the atom of an element.	Last electron	3	2	+2	- 2		
	the quantum numbers of the last electron which has the highest energy	Quantum numbers	(n)	(6)	(m _l)	(m ₅		
18								
	of s and p-blocks.							
	d number of transition elements greater to	than the total number of	of the	elemer	nts			
	© one of the metalloids.							
	ⓑ 32 elements.							
	a 10 metals.							
17	The fourth period in the modern periodi	c table contains						
f 	d has the same electronic configuration of	of argon.						
	© has 18 neutrons.							
	b has the symbol Ar ²⁺							
	(a) its nucleus contains 18 protons.							
16	An ion which contains 18 electrons and i	ts charge is +2,						
	d The element whose atomic number is 5	66 is located in group ((IIIA),	sixth	period.			
4	in group (VB), seventh period.							
i i	© The element whose electronic configur	ation is [Rn], 6d ² , 7s ²	is loca	ated				
1	in group (IIIB), sixth period.							
	b) The element whose electronic configuration is [Xe], $4f^{14}$, $5d^3$, $6s^2$ is located							
	(a) The element whose atomic number is 4	8 is located in group ((IIB), f	ifth pe	eriod.			

- © according to Dalton's atomic model, the elements can combine chemically to form the compounds.
- Rutherford's experiment is the first to discover the presence of the negatively charged electrons in the atom.

- The element whose electron configuration : [Xe], $4f^{13}$, $6s^2$ belongs to
 - (a) the third main transition series.
- (b) lanthanides.
- (c) the second main transition series.
- (d) actinides.
- Which of the following quantum numbers represent one of the electrons of the partially occupied orbitals in the atom of vanadium $_{23}V$?

Choices	m	t	m _t	ms
(1)	3	1	0	$-\frac{1}{2}$
(b)	3	2	0	$+\frac{1}{2}$
©	4	1	0	$+\frac{1}{2}$
(d)	5	2	+1	$-\frac{1}{2}$

The opposite table represents the values of the electron affinities of the halogens.

Fill in the spaces with two suitable values of the following three values:

ĺ	224.5		-400		- 295
ı	- 324.5	2	-400	,	- 293

Element	Electron affinity
Fluorine	– 328 kJ/mol
Chlorine	- 348.6 kJ/mol
Bromine	kJ/mol
lodine	kJ/mol

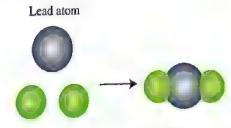
Deduce the relation which is illustrated by the opposite diagram.

by the opposite diagram.



The opposite figure represents one of the postulates of a theory you have studied:

- (1) What is this theory?
- (2) State the postulate illustrated in the figure.

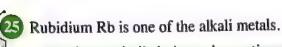


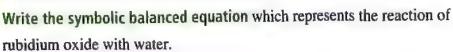
Two chlorine atoms

Lead (II) chloride



243







26 An element contains one electron in the last sublevel, if the quantum numbers of that electron are: $(n = 3, l = 1, m_l = -1, m_s = +\frac{1}{2})$

(1) Calculate the atomic number of the element.

(2) Mention the number of the group in which the element is located.





27 If you know that:

- (O H) bond length in water molecule equals 0.96 Å
- Bond length in oxygen molecule equals 1.32 Å Calculate the bond length in hydrogen molecule.







0	What is t	he block	of the	element	whose	electronic	configuration	İS
	[Kr] ,4d	$10,4f^4,5$	$5s^2, 5p^6$	$6s^2$?				

- a s-block.
- (b) p-block.
- © d-block.
- (d) f-block.

The opposite table shows the first three ionization potentials E_1 , E_2 and E_3 of an element. What is the most stable oxidation state of this element?

\mathbb{E}_1	\mathbf{E}_1 \mathbf{E}_2 \mathbf{E}_3	
7 eV	12.5 eV	42.5 eV

- (a) +1
- (b) +2
- (c) + 3
- (d) +4
- Which of the following valence electrons are affected by the highest effective nuclear charge?
 - (a) 451
- (b) $4p^{I}$
- \bigcirc 3 d^{l}
- (d) $2p^3$
- Four elements P, Q, R and S are located in p-block in the third period in the periodic table, they are ordered according to electronegativity as follows: S > R > Q > PWhich of the following compounds liberates H⁺ ion easier?
 - (a) P−O−H
- (b) 5 O H
- (c) Q O H
- (d) R O H

Iron (II) chloride reacts with chlorine as follows:

Which of the following statements is correct?

- Fe²⁺ ions are reduced to Fe³⁺ ions and chlorine acts as oxidizing agent.
- Fe²⁺ ions lose electrons and chlorine acts as reducing agent.
- Fe²⁺ ions lose electrons and Cl₂ molecules are reduced to Cl⁻ ions.
- Cl, molecules are reduced to Cl ions and chlorine acts as reducing agent.
- What is the symbol of the element which is located in group (3A), fifth period in the periodic table ?
 - 3 13AI
- ⓑ ₂₂Ti
- © 41 Nb
- (d) 40 In

245

An electron with the quantum numbe	rs:
Wil Siection with the degreen name	

$$(n = 4, l = 1, m_l = -1, m_s = +\frac{1}{2}).$$

What is the sublevel of this electron?

- (a) 4s
- (b) 4p
- © 4d
- (d) 4f

What are the two elements which are located in the same period in the periodic table?

- (a) Mg, Sb
- (b) Ca, Zn
- © Na, Ca
- (d) Ca, Cl

What is the proper graduation in electronegativity in these four shown elements?

- \bigcirc C < N < Si < P
- (b) Si < P < C < N
- © N < C < P < Si
- \bigcirc C < Si < N < P
- The opposite table shows the first and second ionization potentials of four elements: P, Q, R and S.

 What is the most active metal in this group of elements?

1	-
(a)	- ">
(- /	-

- © R
- (d) **Q**

		_
Element	First ionization potential	Second ionization potential
S	2372 kJ/mol	5251 kJ/mol
R	520 kJ/mol	7300 kJ/mol
Q	900 kJ/mol	1760 kJ/mol
P	1680 kJ/mol	3380 kJ/mol

- What is the number of elements in the fourth period in the periodic table, in which the orbitals of 3d sublevel are occupied by one electron or more?
 - (a) 16
- (b) 10
- © 9
- (d) 0
- Which of the following electronic transitions in hydrogen atom is accompanied by maximum release of energy?
 - (a) $(n = 2) \longrightarrow (n = 1)$.

(b) $(n = 3) \longrightarrow (n = 2)$.

 $(n = 4) \longrightarrow (n = 3).$

- (d) $(n = 2) \longrightarrow (n = 4)$.
- (B) The maximum value of (m,) for an electron in the fourth energy level is
 - (a) +3
- (b) +4
- © +5
- (d) +9
- Nitrogen has atomic number 7 and oxygen has atomic number 8 What is total number of electrons in $(NO_3)^-$ ion ?
 - (a) 15e⁻
- (b) 31e-
- © 32e
- (d) 46e-

B	The electron configuration Is^2 , 2	$2s^2$, $2p^5$, $3s^I$ sho	10WS
	(a) the ground state of fluorine.		
	(b) an excited state of fluorine.		
	© an excited state of neon.		
	\textcircled{d} the ground state of O^{2-} ion.		
16	Bohr's model could explain succe	essfully the spect	ctrum of
	(a) the multi-electron atoms.		
	(b) helium.		
	© any atom or ion containing only	y one electron.	
	d hydrogen molecule.		
M	According to Hund's rule and Pau	uli's exclusion pr	rinciple, the two last electrons
	which have the highest energy in		
	the two quantum numbers	20	
	(a) (, m,	(b) n, m	n,
	© l, m,	(d) m,, r	
18	The opposite figure represents a		·
	periodic table. In which of the illu		A CD
	a diatomic molecule element whi		A B C D
	conduct electricity is found ?	cii docs not	
	A	() В	
	© C	@ D	
		0	
	Cathode rays are deflected away	from the negati	ively charged metal plate,
	because they are		
	a non-material particles.		tively charged.
	© emitted from all materials.	(d) positi	ively charged.
20	Which of the following is the elec	tron configurati	ion of iron cation in ${ m Fe(OH)}_2$?
	(a) [Ar], $4s^2$, $3d^6$	(kn	nowing that the atomic number of iron = 26)

ⓑ [Ar], $4s^2$, $3d^4$ ⓒ [Ar], $4s^0$, $3d^6$

(d) [Ar], $4s^2$, $3d^8$

(21) Which transformation is an oxidation?

(a)
$$VO_3^- \longrightarrow VO_2^+$$

$$\odot$$
 SO₃ \longrightarrow SO₄²

$$\textcircled{d} NO_3^- \longrightarrow NO_2^-$$

The opposite table shows the values of the quantum numbers of the last electron in the atom of the element (X).

Quantum numbers	(n)	(6)	(m _l)	(m _s)
Element (X)	4	1	0	$+\frac{1}{2}$

Deduce the four quantum numbers of the last electron in the atom of element (Y) which follows element (X) in the same group in the periodic table.



Write the four quantum numbers of the electron number 11 in each of sodium and magnesium atoms.



Figure (1) shows the falling apples and their distribution around the trunk of their tree in circles with different radii:



Figure (1)

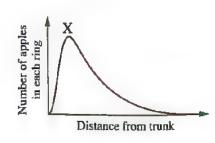


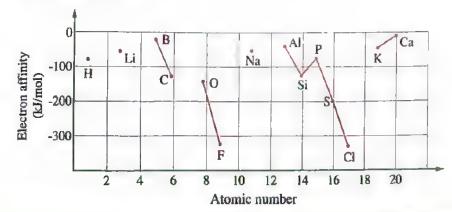
Figure (2)

In the light of understanding the different atomic theories.

What does the symbol (X) in the figure (2) represent?



The following graph represents the values of the electron affinity of the first twenty elements in the periodic table:



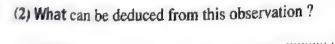
Why were the symbols [He , Be , N , Ne , Mg , Ar] neglected to be mentioned in this graph?

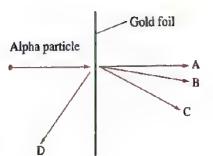
cine Braker					
		*****			***************************************

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			***************	******************	******



- The opposite figure shows the different paths of alpha particles, when a beam of them hits a foil of gold :
 - (1) Which of the shown letters represents the path of one in every 20000 alpha particles?







المعاصر ، كيمياء - لعات (شرح) / ٢٥ (م: ٣٢)

	$[Na_2O]$, $[MgO]$, $[Al_2O_3]$, $[SO_2]$, $[Cl_2O]$
Which	of these oxides :
(1) Inc	cludes the element bound to oxygen which has the highest oxidation number?
Ca	Iculate this oxidation number.
(2) Dis	ssolves in water forming a monoprotic acid,
wr	ite the balanced symbolic equation which represents this.

Exam model



Open Book

Choose the correct answer for the questions 11: 21



Which of the following electronic configurations represents the element that is the most electropositive?

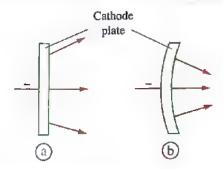
(a) [He], $2s^{I}$

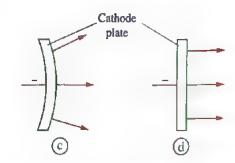
(b) [Ne], $3s^2$

(c) [Xe], $6s^{I}$

(d) [Xe], $6s^2$

Each of the following figures shows the path of the cathode rays emitted from the surface of the cathode plate, except





The element with the least atomic number that has the stable electronic configuration: $(n-1)d^6$, ns^2 is located in the

(a) sixth period.

(b) fifth period.

© fourth period.

(d) third period.

 $oldsymbol{4}$ If the radius of the first orbital in $oldsymbol{H}$ atom equals $oldsymbol{\mathcal{X}}$ $\mathring{oldsymbol{A}}$, so the radius of the second orbital in Li2+ ion is

(a) x Å

ⓑ $\frac{4}{3}x$ Å

 $\bigcirc \frac{9}{2} x \mathring{A}$

(d) 4x Å

Which of the following transfers of the electron of hydrogen atom is accompanied by releasing the largest amount of energy?

(a) n = 4 - - - n = 2

(b) $n = 5 \longrightarrow n = 2$

© $n = 2 \longrightarrow n = 1$

(d) $n = 7 \longrightarrow n = 2$

6 Why are there no values for the electronegativities of the elements whose atomic numbers are 2, 10 and 18?

- (a) Because they are gaseous substances.
- (b) Because they are amphoteric.
- © Because they are radioactive.
- (d) Because their electronic configurations are stable.

What is the number of orbitals in the level (n = 3)?

(a) 3

(b) 5

(c) 7

- **@9**
- What is the similarity between the metal atom M and its ion M³⁺?
 - (a) The radius.

(b) Number of electrons.

© Nuclear charge.

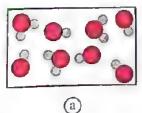
- (d) Ionization potential.
- The following electronic configurations represent four different elements. Which of them has the highest ionization potential?
 - (a) [Ne], $3s^2$, $3p^1$

(b) [Ne], $3s^2$, $3p^3$

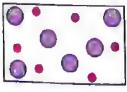
(c) [Ne], $3s^2$, $3p^4$

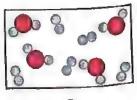
- (d) [Ar], $3d^{10}$, $4s^2$, $4p^3$
- Which of the following equations represents an oxidation-reduction reaction?
 - (a) $CaCl_2 + Na_2SO_4 \longrightarrow CaSO_4 + 2NaCl$
 - ⓑ KOH + HNO₃ → KNO₃ + H₂O
 - \bigcirc $N_2 + O_2 \longrightarrow 2NO$
 - (d) AgNO₃ + NaCl --- NaNO₃ + AgCl
- Mhich of the following choices is incompatible with the building-up principle?

- Which of the following represents a mixture of two of group zero elements?









(b)

Which of the f	ollowing electron configu	urations includes two	unpaired (single)
electrons?			
(a) $1s^2$, $2s^2$		(b) $1s^2$, $2s^2$, $2p^3$	
© $1s^2$, $2s^2$, $2s^2$	p^4	(d) $1s^2$, $2s^2$, $2p^5$	
Which of the f	ollowing processes repre	sents the formation o	f a strong acid
as a result of a	n oxidation process?		
(a) H ₂ SO ₃ —	→ H ₂ S	ⓑ HClO ₄ →	HCI
© H ₂ SO ₃ —	► H ₂ SO ₄	\bigcirc HCO $_3^- \longrightarrow$ H	H ₂ CO ₃
Which of the fo	ollowing elements atoms	releases the highest	amount of energy whe
it gains an elec	ctron in its gaseous state	?	
(a) C	(b) O	© Si	(d) S
The isotopes of	the same element are sir	milar in the atomic nur	nber and different in
the mass numb	er, this fact contradicts th	e postulates of the at	omic theory of
a Bohr.	(b) Rutherford.	© Dalton.	d Thomson.
Which of the fo	ollowing cases represents	s the transfer of an ex	cited electron back to
its ground ene	_		
_	$s^5 \longrightarrow 1s^2, 2s^2, 2p^4, 3$	S^I	
ⓑ $1s^2$, $2s^2$, $2p^2$	$1s^{2}, 2s^{2}, 2s^{2}$	p^6 , $3s^1$	
© [Ar], $4s^2$	\rightarrow [Ne], $3s^2$		
@2,8,7	• [Ne] $, 3s^2, 3p^5$		
The history of I	proving the presence of a	nucleus inside the at	tom of the element
goes back to at			
(a) Bohr.	(b) Thomson.	© Rutherford.	d Heisenberg.
Which of the fo	llowing supports the dua	al nature of the electr	ons ?
(a) The emission	n spectrum of hydrogen at	om.	
	n spectrum of hydrogen at on of some α-particles on		1.
(b) The deflection	n spectrum of hydrogen at on of some α-particles on ion of some α-particles or	collision with gold foi	

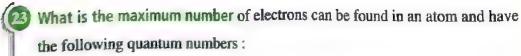
Which of the following choices represents an impossible combination of quantum numbers ?

Choices	(n)	(b)	(m _ℓ)	(m _s ,
(a)	3	2	+2	$-\frac{1}{2}$
Ь	3	1	-1	$+\frac{1}{2}$
0	4	3	+2	+ 1/2
a	5	2	+3	$-\frac{1}{2}$

21 Each of the following matches Pauli's principle, exce	<u>:pt</u>
--	------------

a	1	11	

(22)	What is the difference between the oxidation numbers of potassium
	in potassium permanganate compound and in potassium dichromate compound? Explain.



$$(n = 1, l = 0, m_l = 0)$$

		The	element	First io	nization pot	ential		
		Phos	phorus ₁₅ P	+:	1012 kJ/mo]		
		Sul	phur ₁₆ S	+3	1000 kJ/mo	1		
		***********	**************				*******	
		************	***************************************	***************************************				
			************		, .,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,		**********	
		**********	*****************	*******	····			
			***************************************	***********				
		**************	*****	************			**** **	* ****
		***************************************				**********		(
followi	ng figur	e repres	ents a section	on in the	periodic tab	le.		
P								
							U	
Q	1							
Q								R
Q								R

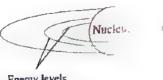
	ater:	_			
2 KOH +	(1)		(2) +	*****	
Alkali Acid	lic oxide		Water	Sait	
(1) Complete the previous diag	ram with	chemical fo	rmulas that	fulfill a com	ect bala
symbolic chemical equation					
(1)	*	(2):	. 4 2 4 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	**********	
(3):					
(2) Deduce the values of (n) an	d (m) of	the oxygena	ited acid whi	ch is produc	ed from
dissolving the acidic oxide -				_	
******* *******************************	,,,,,				410000000

			*****		**********

The following table illustrate	s the val				
	s the val				
The following table illustrate	s the val	lues of the o	ovalent ato		(4
The following table illustrates the molecules of some eleme	s the val	lues of the o	ovalent ato	mic radii of	
The following table illustrates the molecules of some eleme The molecule The covalent atomic radius	s the val nts : H – H 0.3 Å	lues of the c	(2) 1.33 Å	mic radii of (3)	0.64
The following table illustrate the molecules of some eleme	s the val nts : H – H 0.3 Å	lues of the c	(2) 1.33 Å	mic radii of (3)	0.64
The following table illustrates the molecules of some eleme The molecule The covalent atomic radius (1) Complete the blanks in the in the halogens group.	s the val nts : H – H 0.3 Å	lues of the comments of the co	1.33 Å	mic radii of(3) 1.14 Å s of the first	0.64
The following table illustrates the molecules of some eleme The molecule The covalent atomic radius (1) Complete the blanks in the	s the valents: H - H 0.3 Å table w	0.99 Å ith the suitab	(2) 1.33 Å	mic radii of(3) 1.14 Å s of the first	0.64

5	• Choose the correct answer for	1010
1	The visible spectrum of hydrogen atom sho	ws
	(a) the presence of sublevels in each principal	level.
-	(b) the presence of definite energy levels.	
	the possibility of the emission of a quantu	m from the orbital of Is
	d the presence of different isotopes of hydro	gen atom.
	The electronic configuration of the element	(X) ends with the sublevels:
	$(n-1)s^2$, $(n-1)p^6$, $(n-1)d^5$, ns^2	
	If $(n = 4)$, then the atomic number of $(X) =$	
	a 15	b 25
	© 30	① 35
0	The element (X) is located in the third period	od, group (5A) and the element (Y) is
	in the fifth period, group (15).	
1	What is the atomic number of the element	
	<u>a</u> 31	(b) 32
ļ	© 33	d 34
0	In which two compounds of the following the	ne underlined element has the same
	oxidation number ?	
	\bigcirc CrSO ₄ , Cr ₂ O ₃	ⓑ NaClO ₃ , CuCl ₂
	\bigcirc MnCl ₂ , MnO ₂	$\textcircled{d} \underline{SO}_3$, $H_2\underline{SO}_4$
0	All the following are among the conclusions	of Rutherford's experiment,
	except that	
	a) the atom contains vast space.	
	b the nucleus is so much smaller in size than	
	most of the atomic mass is concentrated in	
	(1) the electrons revolve around the atom in de	
3	The maximum number of electrons required	to saturate a sublevel can be estimated
	from the relation	
	(a) 4l+2	(b) $2l + 1$ (d) $4l - 2$
	© 2n ²	(d) 4l - 2

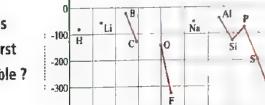
According to the wave mechanical theory, the letter (D) in the opposite figure represents





Energy levels

- (a) a fixed position of the electron.
- (b) the farthest position from nucleus that an electron can reach.
- © a probable position of an electron.
- d an impossible position for an electron.
- Among the properties of the nonmetals is that they
 - (a) are reducing agents.
 - (b) form oxides which react with acids.
 - (c) gain electrons forming cations.
 - (d) are electronegative elements.
- What is the property which is represented by the vertical axis of the opposite graph of the first 20 elements in the periodic table?



10 12

Atomic number

- (a) Atomic radius.
- (b) Electron affinity.
- (c) Ionization potential.
- (d) Electronegativity.
- 10 The number of the electrons of the sublevel d in $_{26}\mathrm{Fe^{3+}}$ ion equals
 - (a) the number of the electrons of the sublevel p in $_7N$ atom.
 - (b) the number of the elements of the second period in the periodic table.
 - © the number of the sublevels in 27Co3+ ion.
 - (d) the number of the electrons of the sublevel p in $_8O^-$ ion.
- Which of the following choices represents the correct ascending graduation in the atomic radius property?

Choices	Smaller radius —— Larger radius				
(a)	Ca ²⁺	K ⁺	Ar		
(b)	Ca ²⁺	Ar	K ⁺		
©	Ar	K ⁺	Ca ²⁺		
(1)	K ⁺	Ca ²⁺	Ar		

Which of the following quantum numbers combinations belongs to an electron that is located in one of 4p orbitals ?

(a)
$$n = 4$$
, $l = 1$, $m_l = 0$, $m_s = +\frac{1}{2}$

(b)
$$n = 4$$
, $l = 1$, $m_l = +3$, $m_s = -\frac{1}{2}$

©
$$n = 4$$
, $l = 2$, $m_l = 0$, $m_s = +\frac{1}{2}$

(d)
$$n = 4$$
, $l = 4$, $m_l = +3$, $m_s = -\frac{1}{2}$

What are the two elements in which electronegativity of the second element is higher than the electronegativity of the first element?

Choices	First element	Second element
(a)	F	Fe
Ъ	Br	CI
0	Li	K
a	S	P

Number of electrons equals number of neutrons in

(I) Which of these choices represents the electron configuration of boron element?

Choices	Is	2s	$2p_x$	$2p_y$	$2p_z$
(2)	11	11	†		
(b)	†	11-	†	†	
0	11	†	†		
(1)	1	† †	†		

Each of the following reactions is an oxidation—reduction reaction, except

ⓐ
$$Cu + Br_2$$
 ← $CuBr_2$

17	Each of the following oxides reacts with sodium hydroxide solution to form a salt,
	<u>except</u>

- (1) Al₂O₃
- (b) P2O5
- © MgO
- d SiO₂
- The photon which is emitted from the electron of hydrogen atom when $\frac{1}{2}$ transfers from 4d to 2s is in the form of
 - (a) infrared ray.
 - (b) ultraviolet ray.
 - © visible ray.
 - d X-ray.
- Which of the following is correct for the properties of the cathode rays?
 - (a) They heat a thin metal sheet that stands in their way as they move in straight lines.
 - (b) They move a light ball of foam as they move in straight lines.
 - © They affected by the electrical field as they are material particles.
 - (d) They heat a thin metal sheet that stands in their way as they have thermal effect.
- Protactinium is one of the actinides and its electronic configuration is
 - (a) [Xe], $6s^2$, $5d^0$, $4f^6$
 - ⓑ [Xe], $6s^2$, $5d^3$, $4f^{14}$
 - © [Rn], $7s^2$, $6d^1$, $5f^2$
 - (d) [Rn], $7s^2$, $6d^4$, $5f^{14}$
- What is the maximum number of electrons which have the spin quantum number $(m_s = +\frac{1}{2})$ in the sublevel $(\ell = 3)$?
 - (a) 3
 - **b** 5
 - © 6
 - d) 7

	fontaction potential (k.f. n =)					
five ionization potentials of	Frist	Second	Third	Fourth		
the element (X).	+738	+1450	+7733	+10543	+1363(
Deduce the formula of the chloride of						
the element (X).						
,		,.,				

					1 mari	
The reaction of acid with sodium carbon	ate salt is in	ndicated b	y the evo	lution of (CO, gas	
bubbles, so if two equal volumes of H ₂ S						
are added to two similar masses of sodiu						
Deduce the name of the acid which for			of bubb	les in		
the beginning of the reaction, with prov					in	
	ing your an	STACE TALES	d Jelene	me proor		
the light of what you have studied.						
the light of what you have studied.				*******		
the light of what you have studied.						
the light of what you have studied.						
the light of what you have studied.						
the light of what you have studied.						
the light of what you have studied.					2 marks	
					2 marks	
Calculate the difference in the number	of the repr	esentativ	e elemen	nts	2 marks	
Calculate the difference in the number	of the repr	esentative	e elemen	nts able.	2 marks	
	of the repr	esentative modern p	e elemen	nts able.	2 marks	
Calculate the difference in the number	of the repr	esentative e modern p	e elemen	its able.	2 marks	
Calculate the difference in the number	of the repr	esentative e modern p	e elemen	its able.	2 marks	
Calculate the difference in the number petween the first period and the second p	period in the	esentative e modern p	e elemen	its able.	2 marks	
Calculate the difference in the number	period in the	esentative e modern p	e elemen periodic t	able.	2 marks	
Calculate the difference in the number petween the first period and the second p	period in the	esentative e modern p	e elemen periodic t	able.	2 marks	



	Element (X)	Elemen*
Quantum numbers of the last electron in the element atom	$(n=1, l=0, m_l=0, m_s=+\frac{1}{2})$	$(n = 2, l = 1, m_l = +1, m_s = +\frac{1}{2})$
Bond length in the element molecule	0.6 Å	1.4 Å
Electronic configuration of the element	(1)	(2)

- (1) Complete the previous table with the electronic configurations of the elements (X) and (Y).
- (2) Predict the bond length of the molecule of the element which precedes the element (Y) in the periodic table.



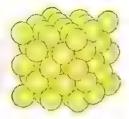
Two electrons in one element atom are located in the first orbital in the same p sublevel in the principal level L

Write the quantum numbers of the two electrons.



The opposite figure represents one of the postulates of an atomic theory that you have studied:





(1) What is this theory?

(2) What is the postulate which is represented in this figure?



Choose the correct answer for the land of

- What is the number of the natural noble gases in which Is orbital is filled with electrons ?
 - (a) 1

b 3

© 5

- (d) 6
- What is the reducing agent in the redox reaction which is represented by the following equation $12H_{(aq)}^+ + 2IO_{3(aq)}^- + 10Fe_{(aq)}^{2+} \longrightarrow 10Fe_{(aq)}^{3+} + I_{2(s)} + 6H_2O_{(l)}$?
 - (a) I₂

(b) H⁺

- © Fe²⁺
- (d) 10,
- A student represented the electron configuration of oxygen atom in its ground state as follows : $1s^2$, $2s^2$, 1

This representation violates

- (a) Hund's rule only.
- (b) Aufbau principle only.
- © Pauli's exclusion principle only.
- d Hund's rule and Pauli's principle.
- All the following sets of quantum numbers are possible, except

ⓐ
$$n = 4$$
, $l = 3$, $m_l = -2$, $m_s = -\frac{1}{2}$

ⓑ
$$n = 5$$
, $l = 3$, $m_l = +2$, $m_s = -\frac{1}{2}$

©
$$n = 3$$
, $\ell = 2$, $m_{\ell} = -1$, $m_{s} = +\frac{1}{2}$

①
$$n = 1$$
, $l = 1$, $m_l = +1$, $m_s = +\frac{1}{2}$

A sample of a compound formed by the combination of 2.69 g of hydrogen with 47.31 g of sulphur.

What is the mass of hydrogen in a sample of the same compound in which the mass of sulphur equals $75.63 \, \mathrm{g}$?

(a) 2.69 g

(b) 1.68 g

© 4.3 g

d 203.4 g

- The two ions $_{27}\mathrm{W}^{2+}$ and $_{28}\mathrm{X}^{3+}$ are similar in all the following, except
 - (a) the number of protons which exist in the nucleus of the atom.
 - (b) the number of electrons of the last principal level.
 - (c) the number of the sublevels which are occupied by electrons.
 - (d) the number of the unpaired electrons in the last sublevel.
- The relation between the electron affinity of sulphur and that of oxygen resembles the relation between the electron affinity of chlorine and that of fluorine.

 Which of these choices represents the correct descending graduation in electron affinity in nitrogen, oxygen and sulphur?
 - (a) S > O > N
 - (b) O>S>N
 - © N > O > S
 - (d) S > N > 0
- 8 Neutral oxides react neither with acids nor with bases.
 Which of the following substances are neutral oxides?
 - a NO2, Na2O
 - (b) CO, NO
 - © SnO, K2O
 - (d) CO2, NO2
- The element whose atomic number is 57 belongs to
 - (a) s-block.
 - (c) d-block.

- (b) p-block.
- d f-block.
- The opposite table shows the quantum numbers (n), (l) of 5 electrons in one atom.

 What is the correct ascending order of the energies of these electrons?

Electron	(I)	(H)	(III)	(IV)	(V)
(n)	3	5	4	4	4
(l)	2	0	1	2	0

- (a) I < V < III < IV < II
- (b) I < V < III < II < IV
- © V < I < III < II < IV
- (I) V < I < II < III < IV

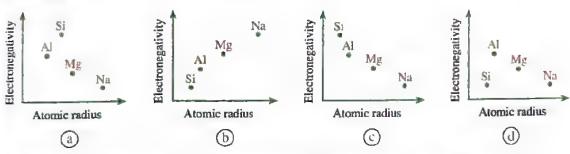
n the reaction :

$$OF_2 + SO_2 \longrightarrow SO_3 + F_2$$

Which is being oxidized and which is reduced in this reaction?

Choices	Fluorine	Oxygen in OF ₂	Sulphur
a	Oxidized	Oxidized	Reduced
Ъ	Oxidized	Reduced	Oxidized
0	Reduced	Oxidized	Reduced
(1)	Reduced	Reduced	Oxidized

Which of the following graphical figures represents the relation between electronegativity of (sodium, magnesium, aluminum and silicon) and their atomic radii?



- The concept of the atom as the smallest unit of matter was adopted by
 - (a) Democritus and Aristotle.
- (b) Boyle and Aristotle.
- © Democritus and Thomson.
- (d) Bohr and Berzelius.
- 13 The line spectrum differs from an element to another due to
- (a) the difference in the number of neutrons in each of them.
 - (b) the difference in the mass number of each of them.
 - (c) the difference in the electronic configuration of each of them.
 - (d) the difference in the number of valence electrons in each of them.
- All the following match Bohr's atomic model, except
 - (a) the line spectrum of hydrogen atom.
- B Pauli's principle.

© Planck's theory.

- d Heisenberg's principle.
- 16 The oxide ion ${}^{16}_{8}O^{2-}$ contains
 - a 8 protons, 10 electrons.

(b) 10 protons, 8 electrons.

© 8 protons, 9 electrons.

(d) 10 protons, 7 electrons.

17	The metal which is less active than potassium but more active than lithium and
	beryllium is
1	

(a) Na (b) Ca

(c) B

(d) Fr

(18) All the following about the periodic table are correct, except

(a) it consists of number of groups more than double the number of periods.

(b) the alkali elements differ in the principal quantum number (n).

© the energy sublevels are filled with electrons according to the uncertainty principle.

d Pauli's principle is applied to every element in the periodic table.

What is the total number of valence electrons in thiosulphate ion $(S_2O_3)^{2-}$?

(a) 28e⁻

(b) 30e⁻

© 32e⁻

d 34e⁻

What are the two quantum numbers which represent the orbitals that are filled successively with electrons in the elements $_{21}$ Sc to $_{30}$ Zn ?

(a) (n = 3, l = 1)

ⓑ (n = 3, l = 2)

© (n = 4, l = 1)

(d) (n = 4, l = 2)

What is the number of the orbitals which are completely filled with electrons in the principal level (n = 3) of iodine atom $_{53}I$?

(a) 9

(b) 10

© 11

d) 12

he fol	owing	Figure	e ren	resent	s a se	ection	in the	modei	m perio	dic tal	ole :		
110 101			ор	. 05011					posic	414 141			
	X	_									Υ	1	
		-						. 			'		
	4	7			_								
/hich o	f the e	emei	nts X	, Y an	d Z h	as the	highes	t seco	nd pote	ntial e	nergy	y ? E	xplain.
A + 4 4 4 7 7 7 7							***********					******	

						,,,,,,,,,		*******			,,,,,,,,,		
									.,		,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,		
						,			•••••••				
«plain	in the li	ght o	of wh	at yo	u hav	ve stu	ıdied,						
	in the li							lphur	ous aci	d H ₂ S	O ₂ ?		·····
	in the li							lphur	ous aci	d H ₂ Se	O ₃ ?		
								lphur	ous aci	d H ₂ S	O ₃ ?		·····
								lphur	ous aci	d H ₂ S	O ₃ ?		
								lphur	ous aci	d H ₂ S	O ₃ ?		·····
								llphur	ous aci	d H ₂ S	O ₃ ?		
								lphur	ous aci	d H ₂ S	O ₃ ?		·····
								lphur	ous aci	d H ₂ So	O ₃ ?		
								lphur	ous aci	d H ₂ S	O ₃ ?		
								lphur	ous aci	d H ₂ So	O ₃ ?		

equals i	Å, and th	e bond lei s longer, i	ngth in th	e molecul	e of hyd	irogen (nolecule of chloride eq the bond in	uals 1.29	
equals i	l Å, and th te which is	e bond lei s longer, i	ngth in th	e molecul	e of hyd	irogen (hloride eq	uals 1.29	
equals i	l Å, and th te which is	e bond lei s longer, i	ngth in th	e molecul	e of hyd	irogen (hloride eq	uals 1.29	
equals i	l Å, and th te which is	e bond lei s longer, i	ngth in th	e molecul	e of hyd	irogen (hloride eq	uals 1.29	
equals i	l Å, and th te which is	e bond lei s longer, i	ngth in th	e molecul	e of hyd	irogen (hloride eq	uals 1.29	
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Chlorin	e atomic ra	adius equa	als 0.99 Å	, the bond	d length	in the	nolecule of	f ammoni	ia
				-				-	2 mar
******			4 4 8 0 m 1 4 4 4 m 2 P 4 A 4 D 1		b: 1000, 1000, 1		,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,		
				_	wo meta	al sheet	s with diffe	erent chai	ges.
(2) Pred	li ct what w	rill happer	to the re	ading of					
meta	al sheet bed	comes pos	itively ch	arged.					
	mes negati								
					α-pa		Metal sheet	to desert a	number o rticles
(1) Illustrate on the figure the path of the beam of α-particles if the upper metal sheet		Sour	rce of		Sensi Ne instrume				
in vacuu	ım conditi						α-particles		
	of ownarti	cles betw	ents the p		ets		Metal sheet		

Complete the blanks which are found below Cr, Cu elements with what is suitable for each of them.

Exam model 10

Open Book

Answere

Choose the correct answer for the question	ns (1): (2)					
Which of the following represents the prop	er graduation in electron affinity?					
③ O > C > N > B	$\bigcirc B > N > C > 0$					
© 0 > C > B > N	(d) O > B > C > N					
2 Breaking (M – O) bond in M – O – H indica	tes that					
(a) the difference in electronegativity between M and O						
is lower than that between O and H						
b the compound is being ionized according	to the reaction medium.					
© the difference in electronegativity between	M and O					
is higher than that between O and H						
d the compound is being ionized as an acid						
Bohr's atomic model can be applied to	*******					
a Na ¹⁰⁺ ion.	(b) He atom.					
© Be ²⁺ ion.	\textcircled{d} C^{6+} ion.					
Which of the following conversions shows	an oxidation and a reduction for					
the same element ?						
$3 N_2 \longrightarrow NH_3 \longrightarrow NO$						
ⓑ C → CO → CO ₂						
\bigcirc PbO ₂ \longrightarrow PbO \longrightarrow Pb						
6 What is the number of the orbitals which (a	(1+l) of its electrons is less than 5?					
a 4 b 8	© 9 @ 10					
6 Which of these electron configurations is in	compatible with both exclusion principle					
and Hund's rule ?						
	(b) 11 11 11 1					
	(d) (1) (1) (1)					

1		
7	The opposite figure represents	Element A
	the line spectra of four elements	Element D Element X
1	A, D, X, and Z, and of a mixture of	Element Z
	two of these elements.	Mixture The Transfer of the Tr
	What are these two elements ?	750 700 650 600 550 500 450 40 Wavelength (nm
	(a) D and A	(b) X and A
(© D and Z	(d) X and Z
8	Which of the following represents cor	rectly the relation between fluorine
] ;	and chlorine atoms ?	
((a) $F_{(g)} < Cl_{(g)}$ regarding the energy relationship	eased from each of them on gaining an electron.
		of them to attract the electrons of $H - X$ bond.
		etween the two atoms of the molecule of
1	each of them.	
		ntum number of the last electron in each of them.
1	The last principal energy level in the	element $X (n = 5)$ contains 5 electrons.
'	What is the type of its oxide X_2O_3 ?	
1	(a) Acidic.	(b) Neutral.
	© Basic.	d Amphoteric.
		d) ramphoterio.
10	Which of the following represents the	correct graduation in the atomic radius ?
	Which of the following represents the \bigcirc F > Cl > S	
		e correct graduation in the atomic radius ?
	② F > Cl > Sⓒ Cl > S > F	(a) S > F > Cl (d) S > Cl > F
	(a) F > Cl > S	e correct graduation in the atomic radius ? (b) S > F > Cl (d) S > Cl > F
	② F > Cl > Sⓒ Cl > S > F	e correct graduation in the atomic radius ? (b) S > F > Cl (d) S > Cl > F
	② F > Cl > Sⓒ Cl > S > F	e correct graduation in the atomic radius ? (b) $S > F > C1$ (d) $S > C1 > F$ tion in the periodic table :
	② F > Cl > Sⓒ Cl > S > F	e correct graduation in the atomic radius ? (b) S > F > Cl (d) S > Cl > F

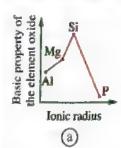
What is the number of the element (X), which is characterized by a large atomic radius and good electric conductivity, and forms with chlorine XCl₂ and XCl₃ compounds?

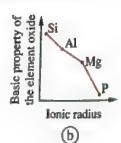
- (1)
- (b) (2)
- © (3)
- (d) (4)

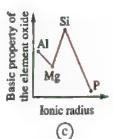
- (P) and (Q) are two atoms of two different elements:
 - Number of protons in atom (P) is less than that in atom (Q) by 9
 - Number of unpaired electrons in atom (P) is more than that in atom (Q) by E What does this indicate about the elements (P) and (Q)?
 - (a) Element (P) is carbon and element (Q) is phosphorus only.
 - (b) Element (P) is nitrogen and element (Q) is sulphur only.
 - © Elements (P) and (Q) may be carbon and phosphorus or oxygen and chlorine.
 - (d) Elements (P) and (Q) may be nitrogen and sulphur or oxygen and chlorine.
- What is the number of the sublevels and that of the orbitals which are occupied by electrons in an ion of a metal whose electron configuration ends with the sublevel $(2p^6)$?

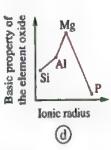
Choices	Number of sublevels	Number of orbitals occupied by electrons
a	6	5
Ъ	5	3
©	5	7
<u>d</u>	3	5

Which of the following graphs represents the relation between the basic property of the element oxide and its ionic radius ?







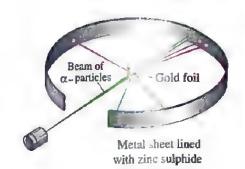


- In which of the following pairs of substances do the nitrogen atoms have the same oxidation state?
 - (a) HNO₃, N₂O₅
 - 6 NO, HNO2
 - © N, , N,O
 - @ HNO2, HNO3

In the experiment which is illustrated in the opposite figure.

What is the postulate which could not be concluded from this experiment?

- (a) The atom is not solid.
- (b) The atom contains a positively charged part.
- © It is possible that the electrons are present in the electron cloud which surrounds the nucleus.
- (1) The dense part in the atom occupies a tiny space.



The following table shows the first seven ionization potentials of the element (X):

ionization potentials (kJ/mol)								
First	Second	Third	Fourth	Fifth	Sixth	Seventh		
+870	+1800	+3000	+3600	+5800	+7000	+13200		

Which of the following statements is true for the element (X)?

- (a) It contains a half filled p sublevel.
- (b) It forms with beryllium a compound whose formula is BeX2
- © It is located in the fourth period in the periodic table.
- d It has a first ionization potential less than that of the element which precedes it in the periodic table.
- The actual path of the last electron in sodium atom cannot be precisely determined, the previous statement is an application of
 - (a) Hund's rule.

(b) uncertainty principle.

© Bohr's rule.

- (d) the dual nature of electron.
- The electronic configuration of molybdenum element 42 Mo is
 - (a) [Kr], 5s1, 4d10

(b) [Kr], $5s^2$, $4d^4$

© [Kr] , 5s¹ , 4d⁵

- (d) [Kr], $5s^2$, $4d^5$
- Which of the following includes an orbital of 3d sublevel that contains one pair of electrons, while its 4s sublevel is completely filled with electrons?
 - (a) ₂₉Cu
- **b** 26 Fe
- © 28Ni²⁺
- (d) $_{38}Sr^{2+}$

Arsenic atom 33As gains 3 electrons when it combines with sodium to focus iteras What are the four quantum numbers of the first electron of these gains a electrons?

(a)
$$n = 4$$
, $l = 0$, $m_l = -1$, $m_s = -\frac{1}{2}$

(b)
$$n = 4$$
, $l = 1$, $m_l = -1$, $m_s = -\frac{1}{2}$

©
$$n = 3$$
, $l = 0$, $m_l = 0$, $m_s = +\frac{1}{2}$

(d)
$$n = 3$$
, $l = 1$, $m_l = -1$, $m_s = -\frac{1}{2}$

What is the block in the periodic table in which most of the metallic elements are located?



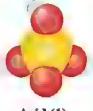
The only compound that Dalton knew the ratios of its components was water (as in the table), he thought that the ratio between the number of hydrogen atoms to the number of oxygen atoms, equals 1:1

Oxygen	Hydrogen
87%	13%

What is the molecular formula of water as Dalton thought?



Arrange the following oxygenated acids ascendingly according to their strength:



Acid (1)



Acid (2)



Acid (3)



المعاصر كيمياء -لغات (شرح) / ٢٠ (م: ٥٠)

Clubbilly the Cichicalian Interest Control	following electronic configuration
two groups, with mentioning the type	e of the elements of each group.
(1) $1s^2$, $2s^2$, $2p^5$	(2) $Is^2, 2s^I$
(3) $1s^2$, $2s^2$, $2p^6$	(4) $1s^2$, $2s^2$, $2p^6$, $3s^2$, $3p^5$
(5) Is^2 , $2s^2$, $2p^6$, $3s^2$, $3p^6$, $4s^1$	(6) $1s^2$, $2s^2$, $2p^6$, $3s^2$, $3p^6$, $4^{-1/2}d^{10}$, 4
.,	
	ur principal energy levels occupied by electron
the last energy sublevel contains thre	e unpaired electrons. Calculate the number of
the last energy sublevel contains thre (1) The orbitals which are completely	e unpaired electrons. Calculate the number of filled with electrons.
the last energy sublevel contains thre (1) The orbitals which are completely	e unpaired electrons. Calculate the number of
the last energy sublevel contains thre (1) The orbitals which are completely	e unpaired electrons. Calculate the number of filled with electrons.

Choose the correct answer for the questions.

- The first assumption : Matter can not be divided infinitely.
- The second assumption : Matter is able to be changed infinitely.

Who were the first to assume these assumptions?

Choices	First assumption	Second assumption
a)	Schrödinger	Heisenberg
Ъ	Bohr	Boyle
0	Dalton	Rutherford
d	Democritus	Aristotle

2	All the following sets o	f quantum	numbers are	possible,	except
---	--------------------------	-----------	-------------	-----------	--------

(a)
$$n = 3$$
, $\ell = 2$, $m_{\ell} = -2$, $m_{s} = +\frac{1}{2}$

(b)
$$n = 4$$
, $l = 0$, $m_l = 0$, $m_s = -\frac{1}{2}$

©
$$n = 3$$
, $\ell = 2$, $m_{\ell} = -3$, $m_{s} = +\frac{1}{2}$

(d)
$$n = 5$$
, $l = 3$, $m_l = 0$, $m_s = -\frac{1}{2}$

Which of the following sublevels can absorb a photon but can not lose one?

(a) 3d

(b) 2p

(c) 1s

(d) 2s

Which of these elements can have positive or negative oxidation number in its compounds?

(a) Cesium.

(b) Fluorine.

© Iodine.

d Krypton.

Assuming disregarding aufbau principle.

What is the block which calcium element would belong to?

a s-block.

b p-block.

© d-block.

(d) f-block.

Two aqueous solutions, which are :

• The first : M₁ – O – H

The second: M₂ – O – H

If the electronegativities of the elements are : [$M_1 = 3.4$, $M_2 = 1.2$, O = 3.5, H = 2.1]. What are the types of the two solutions ?

Choices	First solution	Second solution
(3)	Acidic	Basic
Ъ	Acidic	Acidic
0	Basic	Acidic
(1)	Basic	Basic

What is the electron configuration of the valence electrons of the element whose atomic number is 23?

- (a) 3d⁵
- © $3d^2$, $4s^1$, $4p^1$

- (b) $3d^3$, $4s^2$
- (d) $4d^3$, $4s^2$, $4p^1$

8 Metals which are located in the beginning of each period are characterized by

(a) small atomic radius.

(b) high ionization potential.

(c) high electronegativity.

d low ionization potential.

What is the maximum number of electrons that have the quantum numbers (n = 3), (l = 2)?

(a) 2

b 8

© 10

(d) 18

Which of the following elements is the strongest reducing agent?

(a) Al

(b) Mg

 \bigcirc Zn

(d) Cu

What is the equation which represents the first ionization potential of barium?

(a) $Ba_{(g)} \longrightarrow Ba_{(g)}^+ + e^-$

(b) $Ba_{(g)}^+ \longrightarrow Ba_{(g)}^{2+} + e^-$

© $Ba_{(g)}^{2+} + e^{-} \longrightarrow Ba_{(g)}^{+}$

(d) $Ba_{(g)} \longrightarrow Ba_{(g)}^+ + e^-$

(X) and (Y) are two different elements in the third period in the periodic table, so if:

- The oxide of the element (X) is insoluble in water but it reacts with each of NaOH and HCl
- The chloride of the element (Y) is soluble in water forming colourless acidic solution.

Which of the following choices represents the elements (X) and (Y)?

Choices	Element (X)	Element (Y)
(a)	A1	Р
ь	Al	7,
©	Mg	D
d	Mg	Si

The element (Q) forms an ion having the following properties:

- Has the same electron configuration of the noble gas which precedes it in the periodic table.
- Number of its protons is higher than that of its electrons.
- Formed by losing electrons from one orbital.

Which of the following elements is likely to be element (Q)?

(a) Aluminum (13Al).

(b) Calcium (20Ca).

© Copper (20Cu).

(d) Sulphur (16S).

The first ionization potential of element (Y) is higher than that of element (X). What are the two elements (X) and (Y)?

Choices	Element (X)	Element (Y)
(1)	₁₂ Mg	₁₃ Al
Ь	7N	_g O
0	10Ne	₁₁ Na
(1)	₁₉ K	₁₁ Na



What is the reducing agent in the reaction : $H_2S + I_2 \longrightarrow S + 2H^+ + 2I^-$?

(1) H,S

(b) I₂

(d) H+

Which of the following statements represents properly the effective nuclear charge?

- (a) It decreases in the same period in the periodic table by increasing the atomic number.
- (b) It increases in the same period in the periodic table with moving from left to right.
- It does not change in the same period in the periodic table by increasing the atomic number.
- (i) It increases then decreases in the same period in the periodic table with moving from left to right.

Which of the following choices states the types of lithium and magnesium elements?

Choices	Lithium	Magnesium
(3)	Nonmetal	Metal
Ь	Nonmetal	Nonmetal
©	Metal	Metal
a	Metalloid	Metalloid

(IB) Which of the following choices represents the electron affinity of chlorine?

$$(a) Cl_{(g)}^{-} \longrightarrow Cl_{(g)}^{+} + e^{-}$$

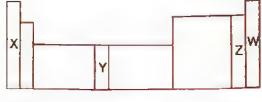
©
$$Cl_{(g)}^- \longrightarrow Cl_{(g)}^{2-} + e^-$$

The opposite figure represents a section in the periodic table.

Which of the following groups its elements exist as monatomic gases?



(L) Z



ⓑ Y

(d) W

What is the electronic configuration of the first element in p-block in the fourth period in the periodic table ?

(a) [Ar]
$$,4s^2$$
 $,3d^{10}$ $,4p^1$

© [Kr],
$$5s^2$$
, $4d^{10}$, $5p^1$

d-finite proportio	in.
definite proportio	
	c theory which explained the law of definite proportion simp
a Dalton's atomic	
b) Thomson's ator	
© Bohr's atomic t	theory.
(d) Rutherford's ato	omic theory.
Mar Doubl's sainting	le applied to the distribution of the electrons in the following or
vas raun s princip Explain.	ile applied to the distribution of the elections in the following of
Apidiii.	
	$\begin{array}{c cccc} TT & 1V & 1V & T \\ \hline Is & 2s & 2p \end{array}$
	19 20 2p
Vhy is it difficult t	to obtain M ²⁺ ion from the element which is located
n the third period,	
· · · · · · · · · · · · · · · · · · ·	
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	
**********************	.,,,,,
lustrate the oxidia	zing agent and the reducing agent in the reaction which
represented by ti	he equation: $6H^+ + 6I^- + ClO_3^- \longrightarrow 3I_2 + 3H_2O + CI^-$
, -	

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	The oppo		_					ng gunh l	of			N. T.	4	5 m	No.	À	6		,
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	Which of																		
	determini																		
	precisely		wh	om	this	assi	ump	tion	l IS										
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	and the																1		
	(1) Deter	rmin	e th	e lo	catio	on of	thi	s ele	mei	it in	the	moo	iern	per	lodic	e tat	ne.		
	(2) What	is th	ne b	lock	of t	his e	elen	nent	?		****		<b>b</b>				*****		
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		H	D.											В	C	N	0	F	Ne
		0.4	DE											Al	Si	P	S	_	
		Li	Ma	1		V	Cr	Mn	Fe	Co	NI	Cu	Zn			-		-	Kr
		Na			Ti					-			-			Sb	$\vdash$	I	
		Na	Ca	Sc		-	Ma	Te	I K U										Xe
		Na	Ca			Nb	Mo	Tc	Ku	*****				1			10	1	Xe
	(1) <b>W</b> hat	Na K Rb	Ca Sr	Sc	Zr	Nb				1	<u> </u>	1		this	sec		L.,	1	Xe
	(1) What	Na K Rb	Ca Sr	Sc	Zr	Nb				1	<u> </u>	1		this	sec		L.,	1	Xe

### Exam model 7

### Open Book

#### Choose the correct answer for the questions 11:21





What is the electron configuration which is consistent with Pauli's principle?

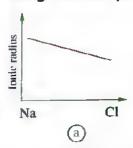
(a) 
$$1s^2$$
,  $2s^2$ ,  $2p^7$ 

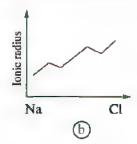
(b) 
$$1s^2$$
,  $2s^2$ ,  $2p^6$ ,  $3s^3$ 

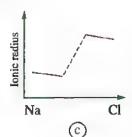
© 
$$1s^2$$
,  $2s^2$ ,  $2p^6$ ,  $3s^2$ ,  $3p^6$ ,  $4s^2$ ,  $3d^{12}$ 

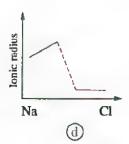
(d) 
$$1s^2$$
,  $2s^2$ ,  $2p^6$ ,  $3s^2$ ,  $3p^6$ 

Which of the following graphical figures represents the change in the ionic radius along the third period elements from Na to CI?









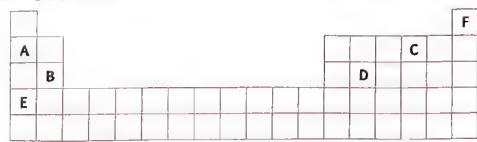
The following reaction represents the total reaction in the rechargeable What are the oxidation numbers of nickel before the beginning of the reaction and at the end of it respectively?

$$(a) +1.5, +2$$

$$(d) + 3, +2$$

What is the least principal quantum number (n) of the two electrons in the first orbital in d sublevel?

The following figure represents a section in the periodic table.



What is the choice which represents the movement from a metal to a metalloid?

Alumin	num.	(	b) Silicon.	
© Phospi	horus.	(	d Sulphur.	
Which of	the following cho	ices is correct?		
Choices	$Cl_{(g)} \longrightarrow Cl_{(g)}^-$	$Cl_{(g)}^{-} \longrightarrow Cl_{(g)}$	$Cl_{(g)} \longrightarrow Cl_{(g)}^+$	Cl ⁺ _(g) > (1)
(a)	Electron affinity	Ionization potential	_	-
Ъ	-	Ionization potential	Ionization potential	_
(C)	Electron affinity	-	-	Ionization potent
<b>a</b>	_		Ionization potential	Electron affinity
_		nuclei falls on a gol	d sheet, it is deflect d sheet, it is deflect atom are distinct in	ed.
The two e	electrons of the sa	nuclei falls on a gol	d sheet, it is deflect	ed.
The two e	electrons of the sa	nuclei falls on a gol	d sheet, it is deflect	ed.
The two enumber	electrons of the sa	nuclei falls on a gol ame orbital in any a	d sheet, it is deflect	ed. the quantum
The two enumber  m _s What is th	electrons of the sa b n	nuclei falls on a gol ame orbital in any a	d sheet, it is deflect atom are distinct in	ed. the quantum
The two enumber  m _s What is th	electrons of the sa b n	nuclei falls on a gol ame orbital in any a n _l	d sheet, it is deflect atom are distinct in	ed. the quantum
The two enumber  a m _s What is the iron atom a 2	b n ne number of electrons of the same number of electrons	nuclei falls on a gol ame orbital in any a n _l ctrons which have t	d sheet, it is deflected to the deflecte	ed.  the quantum  d n  ers (n = 3), ( <i>l</i> = 2
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The two enumber  a m _s What is the iron atom a 2  Bohr's the that a the ele b the ele	electrons of the same number of electrons move in the	nuclei falls on a gol ame orbital in any a m _l ctrons which have t c structure agrees	d sheet, it is deflected to atom are distinct in the quantum number of the quantum number of the quantum number of the quantum number of the quantum number of the modern are nucleus.	ed.  the quantum  a n  ers (n = 3), (l = 2)  a 8  tomic theory on

Choices	Cu	Cu ⁺	Cu ²⁺
(3)	$[Ar], 4s^{I}, 3d^{IO}$	[Ar], 3d ¹⁰	[Ar], 3d ⁹
Ь	$[Ar], 4s^2, 3d^9$	$[Ar], 4s^1, 3d^9$	[Ar], 3d ⁹
(C)	[Ar], 4s ¹ , 3d ¹⁰	$[Ar], 4s^I, 3d^9$	$[Ar], 4s^1, 3d^8$
(1)	$[Ar], 4s^2, 3d^9$	$[Ar], 4s^2, 3d^8$	$[Ar], 4s^2, 3d^7$

 $oxed{ extbf{figure}}$  Which of the following equations represents the second ionization potential of oxygen ?

(a) 
$$O_{(g)} \longrightarrow O_{(g)}^{2+} + 2e^{-}$$

$$\bigcirc O_{(g)} \longrightarrow O_{(g)}^+ + e^-$$

© 
$$O_{(g)}^- + e^- \longrightarrow O_{(g)}^{2-}$$

(d) 
$$O_{(g)}^+ \longrightarrow O_{(g)}^{2+} + e^-$$

Why does the absorption spectrum of hydrogen contain separate lines?

- (a) Because there are certain energy levels in which the electron is allowed to revolve.
- b Because it contains only one electron.
- © Because it contains only one proton.
- d Because the spectrum is recorded at low temperature.

(IB) The following ionic equation represents one of the chemical reactions:

$$MnO_{4(aq)}^{-} + 8H_{(aq)}^{+} + 5Fe_{(aq)}^{2+} \longrightarrow Mn_{(aq)}^{2+} + 4H_{2}O_{(l)} + 5Fe_{(aq)}^{3+}$$

Which of the following statements is correct?

- (a) Each Fe²⁺ ion gains 5 electrons.
- (b) Each H+ ion is oxidized.
- © The oxidation number of Mn is changed from -1 to +2
- (d) The oxidation number of Mn is changed from +7 to +2

What happens to the spaces between energy levels on moving from (n = 1) to (n = 7)?

- a Decrease by increasing (n).
- (b) Do not change.
- © Increase by increasing (n).
- d Change irregularly.

- On moving in group (1A) from lithium to rubidium .....
  - (a) the atomic radius decreases.
  - (b) the ionic radius increases.
  - c) the first ionization potential increases.
  - d the electronegativity increases.
- (R) and (T), if the element (R) is located in group (4A) and the element (T) is located in group (6A).

What is the formula of the compound produced from the combination of the two elements?

a RT

(b) RT₆

© RT₂

- (d) R₂T
- The following table represents the properties of four elements (W, X, Y and Z) in the third period in the periodic table:

Element	(W)	(X)	(Y)	(Z)
Reaction with cold water	Reacts vigorously	Does not react	Reacts slowly	Reacts slowly
Reactions of the element oxide	Reacts with acids	Reacts with bases	Reacts with acids and bases	Reacts with acids

Which of the following choices represents increasing the atomic number of these elements?

 $\bigcirc$  W < X < Y < Z

 $\bigcirc$  Y < W < X < Z

- $\bigcirc$  Z < X < Y < W
- 20 Each of the following can be confirmed undoubtedly, except .....
  - (a) the number of energy levels which are occupied by electrons in 12Mg atom.
  - (b) the number of orbitals which are occupied by unpaired electrons in 26Fe atom.
  - c) the position and the speed of the electron in hydrogen atom at a certain moment.
  - d the difference of the properties of the cathode rays with the difference of the type of the substance of the cathode.

(a) principal level. (b) sublevel. (c) orbital. (d) atoms of the elements of the same period.  Why is the electronic configuration (1s², 2s², 2p²) incorrect?  How many unpaired electrons are present in 27Co³+ ion in its gaseous ground state?  What are the types of the elements which are found in the sixth period in the periodic table?  The opposite figure represents one of the postulates of an atomic theory that you have studied: (1) What is the name of this theory?  (2) State the postulate represented in the figure.	The two electrons which have the same $\ell$ and $m_\ell$ values are located in the same
© orbital.  ② atoms of the elements of the same period.  Why is the electronic configuration (1s², 2s², 2p²) incorrect?  How many unpaired electrons are present in 27Co³+ ion in its gaseous ground state?  What are the types of the elements which are found in the sixth period in the periodic table?  The opposite figure represents one of the postulates of an atomic theory that you have studied:  (1) What is the name of this theory?  (2) State the postulate represented in the figure.	a principal level.
why is the electronic configuration ( $Is^2$ , $2s^2$ , $2p^7$ ) incorrect?  How many unpaired electrons are present in $_{27}Co^{3+}$ ion in its gaseous ground state?  What are the types of the elements which are found in the sixth period in the periodic table?  The opposite figure represents one of the postulates of an atomic theory that you have studied:  (1) What is the name of this theory?	(b) sublevel.
What are the types of the elements which are found in the sixth period in the periodic table?  What are the types of an atomic theory that you have studied:  (1) What is the name of this theory?	© orbital.
How many unpaired electrons are present in 27Co ³⁺ ion in its gaseous ground state?  What are the types of the elements which are found in the sixth period in the periodic table?  The opposite figure represents one of the postulates of an atomic theory that you have studied:  (1) What is the name of this theory?  (2) State the postulate represented in the figure.	d) atoms of the elements of the same period.
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(1) What is the name of this theory?  (2) State the postulate represented in the figure.	
(2) State the postulate represented in the figure.  2 murks	(1) What is the name of this theory?
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[285]	2 000

	$Zn_{(g)} + S_{(g)} \longrightarrow Zn_{(g)}^{2+} + S_{(g)}^{2-}$
(1)	) What is the name of the required energy when $Zn_{(g)}$ is converted to $Zn_{(g)}^+$ ?
(2)	Suggest one use for the solid substance which is produced from the combinant
	of the previous cation and anion.
h	osphoric acid H ₃ PO ₄ is used in the industry of phosphate fertilizers :

(2) Write the balanced symbolic equation which represents the reaction

of phosphoric acid with magnesium oxide.

### Exam model 13

### **Open Book**

Answere

Choose the correct a	inswer for the	questions (1	: 21
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#### The ability of the gases to conduct electricity can be enhanced by ......

- (a) increasing the gas pressure as well as the potential difference between the two electrodes of the conducting tube.
- (h) decreasing the gas pressure as well as the potential difference between the two electrodes of the conducting tube.
- © decreasing the gas pressure and increasing the potential difference between the two electrodes of the conducting tube.
- d increasing the gas pressure and decreasing the potential difference between the two electrodes of the conducting tube.

### The energies of the different orbitals in the atom or ion which contains one electron depend on ......

a n only.

 $\bigcirc$  n and  $\ell$  only.

© n, l and m, only.

- d n,  $\ell$ , m, and m_s
- Which of the following sets of atomic numbers belongs to elements located in group 16 in the periodic table ?
  - (d) 8, 16, 32, 54

(b) 16,34,54,86

© 8, 16, 34, 52

- (d) 10, 16, 32, 50
- What is the electron configuration which represents an excited atom?
  - (a) [Ne],  $3s^2$ ,  $3p^6$ ,  $4s^2$ ,  $3d^8$
  - ⓑ [Ne],  $3s^2$ ,  $3p^6$ ,  $4s^1$ ,  $3d^5$
  - © [Ne],  $3s^2$ ,  $3p^6$ ,  $4s^2$ ,  $3d^1$
  - (1)  $1s^2$ ,  $2s^2$ ,  $2p^5$ ,  $3s^1$
- Which of the following elements atoms gains an electron with higher difficulty than others ?
  - Radon.

(b) Nitrogen.

Oxygen.

(d) Radium.

6	The opposite table shows the oxidation numbers
1	of three elements A , B and C in a compound.
	What is the probable molecular formula of this

Element	3	C
Oxidation number +-	+5	-2

compound?

Each of the following relations represents correctly one property in the elements of the periodic table, except ......

Choices	Relation	Property		
(a)	$Fe^{3+} > Fe^{2+}$	Ionic radius		
<b>6</b>	O > N	Second ionization potential		
©	Cu > Zn	Atomic size		
(1)	Ti > In	First ionization potential		

- How many quanta are released when the electron in hydrogen atom jumps from (n = 4) to (n = 1)?
  - **a** 6

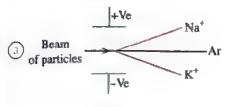
**b** 3

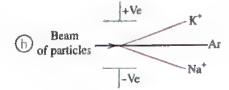
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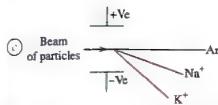
- **d** 1
- What is the number of the points in  $2p_x$  orbital in which the electron density equals zero?
  - (a) Zero
  - **b** 1
  - © 2
  - (d) Infinite number.
- Which of the following groups includes metalloids?
  - (a) Group 8
  - (b) Group 16
  - © Group 2
  - d Group 18

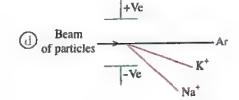
A beam of Na⁺, K⁺ and Ar particles passes between two charged plates.

What is the correct figure which represents the effect of the charged plates on these particles?









The opposite compound is formed of four elements W , X , Y and Z, which are located in different groups in the periodic table.

What are the numbers of the groups of this compound elements in the periodic table?

$$Z - W \equiv W - \begin{matrix} Z & Y \\ I & X - W - Z \\ I & I \\ Z & Z \end{matrix}$$

Choices	(W)	(X)	(Y)	(Z)	
(a)	Group (3A)	Group (5A)	Group (6A)	Group (1A)	
(b)	Group (4A)	Group (3A)	Group (6A)	Group (7A)	
(0)	Group (3A)	Group (5A)	Group (2A)	Group (1A)	
(d)	Group (4A)	Group (5A)	Group (6A)	Group (7A)	

Which of the following diatomic molecules has the shortest bond length?

$$\bigcirc$$
  $N_2$ 

$$\bigcirc F_2$$

$$\bigcirc$$
  $S_2$ 

Which of the following changes represents an oxidation process?

$$\bigcirc NO_2^- \longrightarrow N_2$$

(d) 
$$CrO_4^{2-} \longrightarrow Cr_2O_7^{2-}$$

### The following table represents a section in the periodic table :

	Groups							
Periods	(1A)	(2A)	(3A)	(4A)	(5A)	(6A)	(7A)	(1)
(2)	V	W					X	
(3)	Y						Z	

#### Which of the following statements is correct?

- (a) Element (V) is more active than element (Y).
- (b) Element (Z) is more active than element (X).
- © The electronegativity of element (Y) is less than that of element (V).
- (1) The metallic property of element (W) is stronger than that of element (V).

#### Each of the following electron configurations is consistent with Hund's rule, except .........

- a [] []
- **b 11 1**
- O 11 11 11 1

## What are the possible values of the quantum numbers n and $m_l$ of an electron in one of the orbitals of 5p sublevel ?

(a) 
$$n = 1, 2, 3, 4, 5/m_l = +1$$

(b) 
$$n = 1, 2, 3, 4, 5/m_l = -2, -1, 0, +1, +2$$

© 
$$n = 5 / m_t = -1, 0, +1$$

(d) 
$$n = 5 / m_l = +1$$

#### 18 The nucleus of manganese atom Mn contains 25 protons.

### What is the electron configuration of manganese in $Mn_3(PO_4)_2$ ?

(d) [Ar], 
$$3d^6$$

© [Ar], 
$$3d^3$$
,  $4s^2$ 

① [Ar], 
$$3d^5$$
,  $4s^2$ 

The opposite table represents the values of the first five ionization potentials of an element in the third period. Which of the following illustrates the correct sequence of the orbitals from which the five electrons are lost in the different ionization processes?

+578	+1817	+2745	+11578	+14831		
First	Second	Third	Fourth	Fifth		
Ionization potentials (k,J/mol)						

- (a)  $1s \longrightarrow 2s \longrightarrow 2p \longrightarrow 3s \longrightarrow 3p$  (b)  $1s \longrightarrow 1s \longrightarrow 2s \longrightarrow 2s \longrightarrow 2p$
- (c)  $3p \longrightarrow 3s \longrightarrow 2p \longrightarrow 2s \longrightarrow 1s$  (d)  $3p \longrightarrow 3s \longrightarrow 3s \longrightarrow 2p \longrightarrow 2p$
- 20) Which of these elements their number is the highest in the fourth period in the periodic table?
  - a p-block elements.

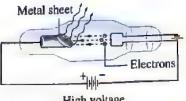
(b) Representative elements.

(c) Transition elements.

- (d) Metals.
- What is the chemical formula of the oxygenated acid which is formed of hydrogen, bromine and oxygen elements and the ratio of (n : m) in it is (1 : 1)?
  - (a) HBrO_A
- (b) HBrO
- © HBrO,
- (d) HBrO₃
- Calculate the bond length in a formula unit of lithium chloride in terms of the radii which are illustrated in the following table:

	Li	Li ⁺	Cl	CF	
The radius	1.57 Å	0.68 Å	0.99 Å	1.81 Å	

Does the opposite figure represent a cathode tube? Confirm your answer with one reason from what you have studied.



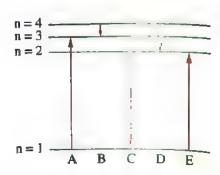
High voltage



The opposite figure represents the several transitions of an electron in one of the atoms.

Which of these transitions represents an emission

quantum (photon) ? Explain.



I mark

The opposite figure represents
the locations of the elements W , X , Y and Z
in the periods (2) and (3) in the periodic table,
the element Y reacts with chlorine forming
YCl_s compound.

Second period		W		
Third period	X		Y	Z

Answer the following:

- (1) Determine the number of the group of the element (X).
- (2) What is the maximum oxidation number of the element (Z) in its compounds?

(....)

(.....)



Study the following scheme, then answer the following:

$$\begin{array}{c|c} + H_2SO_4 & Compound (Y) + H_2O \\ \hline & + 2NaOH & Compound (Z) + H_2O \end{array}$$

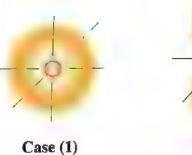
(1) Write the electronic configuration of the cation of the compound (Y).

....

(2) What is the name of compound (Z)?

2 marks

77 The following figures illustrate the possible electron cloud of the excited hydrogen electron in two different cases:





(1) Write the possible (1) and (m1) values of each electron in these two cases.

(2) What is the principal quantum number (n) which is not possible for this electron in the two cases?



# Exam model 14

# Open Book

Answered

- In the equation :  $4Al + 3O_2 \longrightarrow 2Al_2O_3$  when aluminum loses 12 mol of electrons, so oxygen ..........
  - (a) gains 4 mol of electrons.
- (b) gains 12 mol of electrons.
- © loses 4 mol of electrons.
- (d) loses 12 mol of electrons.
- Which of the following choices represents the quantum numbers of the 19th electron in the atom of an element with atomic number 24 ?

Choices	n	l	$\mathbf{m}_{t}$	m _s
(2)	4	0	0	$+\frac{1}{2}$
ь	4	1	-1	$-\frac{1}{2}$
0	3	2	+2	+ 1/2
(d)	3	2	-2	$-\frac{1}{2}$

Which of the following represents the electron configuration of sodium atom in the ground state that violates aufbau principle only?

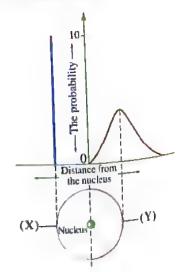


**b 1 1 1 1 1** 



Which of the following describes each of (X) and (Y) in the opposite figure ?

Choices	(X)	(Y)	
3	Orbital	Orbital	
6	Orbit	Electron cloud	
0	Orbit	Orbital	
(1)	Orbit	Orbit	



(5)	The following electron configurations belong to the atoms of known	elements,
1	except	

(a) [Kr], 
$$5s^2$$
,  $4d^8$ 

© [Ar], 
$$4s^1$$
,  $3d^5$ 

ⓑ [Kr], 
$$5s^2$$
,  $4d^{10}$ 

#### Based on the equation and the table :

$$K_{(g)} + Cl_{(g)} \longrightarrow K_{(g)}^+ + Cl_{(g)}^- \quad \Delta H = ?$$

What is the value of  $\Delta H$  of this process?

- (a) 1303 kJ/mol
- (b) 1207 kJ/mol
- © 767 kJ/mol
- d 69 kJ/mol

	lonization potential	Electron affinity
Potassium	+418 kJ/mol	-48 kJ/mol
Chlorine	+1255 kJ/mol	-349 kJ/mol

- Which of the following elements is located in the fourth period, where the value of (n) of its last electron is as high as possible and its ( $\ell$ ) value is the least?
  - a Calcium.

(b) Manganese.

© Tin.

- (d) Cesium.
- What are the two ions forming Li₃N?

(a) 
$$Li^+$$
,  $N^{3-}$  (b)  $Li_3^+$ ,  $N^-$ 

(d) 
$$Li^{3+}$$
,  $N^{3-}$ 

The following equations represent the probable reactions of the oxides of the two metals (M) and (X) with hydrochloric acid and sodium hydroxide.

$$^{\bullet}$$
 MO_(s) + 2HCl_(aq)  $\longrightarrow$  MCl_{2(aq)} + H₂O_(l)

$$^{\circ}$$
 XO_{2(g)} + 2NaOH_(aq)  $\longrightarrow$  Na₂XO_{3(aq)} + H₂O_(l)

What are the probable symbols of (M) and (X)?

Choices	Element (M)	Element (X)	
<b>a</b>	Al	Cl	
<b>b</b>	К	С	
0	Mg	С	
(d)	Na	Cl	

Assisted by the values of electronegativity shown in the table.

What is the correct order of the strengths of these acids ?

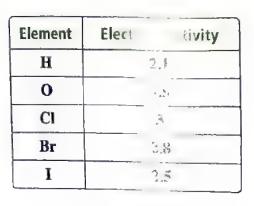
- (a) HIO > HBrO > HClO
- (b) HClO > HBrO > HIO
- © HIO > HCIO > HBrO
- (d) HBrO > HClO > HIO

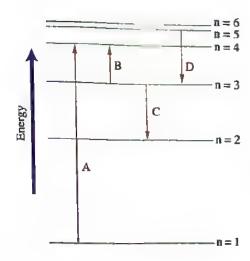
H	The opposite figure illustrates some travels
	of the electron of hydrogen atom between
	the different energy levels.
	Which of these lines represents a visible

spectral line of hydrogen atom?



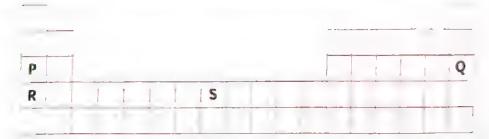
- (b) B
- @ C
- (d) D





- A transition metal ion  $X^{3+}$  its electron configuration is : [Ar],  $3d^4$  What is the atomic number of the element (X)?
  - 22
  - **b** 24
  - **25**
  - d 26
- The chemical formula of the mineral talc (magnesium silicate) is :  ${\rm Mg_3Si_4O_{10}(OH)_2}$ What is the oxidation number of silicon in the mineral talc ?
  - (2)-4
  - (b) -2
  - (c) +2
  - (d) +4

#### The following figure represents a section in the periodic table:



What is the proper order which represents the gradual ascending in the metallic property of the illustrated elements in this section?

$$\bigcirc$$
 Q < R < P < S

(13) Which of the following equations represents the third ionization energy of bismuth Bi element?

(a) 
$$Bi_{(g)}^+ \longrightarrow Bi_{(g)}^{3+} + e^-$$

(b) 
$$Bi_{(s)}^{2+} \longrightarrow Bi_{(s)}^{3+} + e^{-}$$

$$\bigcirc Bi_{(g)}^{2+} + e \longrightarrow Bi_{(g)}^{3+}$$

(d) 
$$Bi_{(g)}^{2+} \longrightarrow Bi_{(g)}^{3+} + e^{-}$$

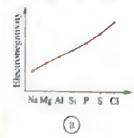
16 What are the assumed quantum numbers of the electron which is added to gallium ( $_{31}{
m Ga}$ ) atom when this electron is in its stable state ?

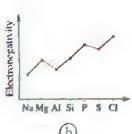
(a) 
$$n = 4$$
,  $l = 1$ ,  $m_{\ell} = 0$ ,  $m_{s} = +\frac{1}{2}$  (b)  $n = 3$ ,  $l = 2$ ,  $m_{\ell} = +2$ ,  $m_{s} = +\frac{1}{2}$ 

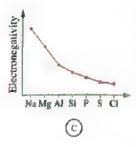
ⓑ 
$$n = 3$$
,  $l = 2$ ,  $m_l = +2$ ,  $m_s = +\frac{1}{2}$ 

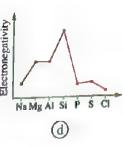
© 
$$n = 4$$
,  $l = 0$ ,  $m_l = 0$ ,  $m_s = +\frac{1}{2}$ 

17) Which of the following graphical figures represents the graduation of the electronegativity property in the elements of the third period (excluding argon)?







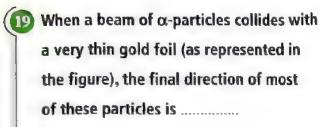


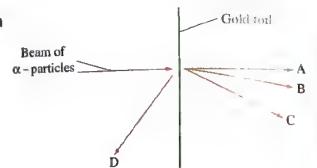
- B The most active nonmetal in the periodic table is the element which is ......
  - d the last in group zero.

(b) the first in group (7A).

() the last in group (2A).

(d) the first in group (5A).





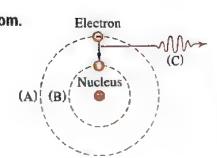
- (a) A
- (b) B
- © C
- (d) D

#### Which of the following electron configurations violates Pauli's principle?

- **a 1 1 1**
- **D 1 1 1**
- **1 1 1 1**
- The opposite figure represents an excited hydrogen atom.

  What is the name of (C) which is produced from the movement of the electron from level

  (A) to level (B) ?



- (a) Excited electron.
- (b) Stable electron.
- Quantum.
- Wisible spectrum.

(22)	What is the block of	the elements which contains	the highest number
1	of the fifth period ele	ments in the periodic table?	



occupied by electi	ons in the actinides.		
			.,
		1 000 00 C	. 4 7 70
		10 g is composed of 92.3% C at	na 7.7%
	ntage of carbon and hydrog		
	und its mass is 5 g ? Explai		
What is the name	of the first scientist who s	uggested this answer?	
,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	***************************************		
			***
~			
		,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	
		,	
	norbromic acid HRrO, and	d hypobromous acid HBrO in	terms
	perbromic acid HBrO ₄ and acid, with explanation.	d hypobromous acid HBrO in	terms
		d hypobromous acid HBrO in	terms
1) Strength of the	ncid, with explanation.		terms
1) Strength of the			terms
1) Strength of the	ncid, with explanation.		terms
1) Strength of the	ncid, with explanation.		terms
1) Strength of the	ncid, with explanation.		terms
1) Strength of the	ncid, with explanation.		terms

n the periodic	table :			
(A)	(B)	(C)	(D)	(E)
[Ne] , 3s ¹				
	ymbolic equation ) with water.	which represents	the reaction of o	one of the oxide
		which represents	the reaction of o	one of the oxides
element (E	) with water.	which represents		
clement (E	ent and strontiur		cated in the seco	ond group

(2) What is the number of the orbitals which are occupied by electrons in calcium atom

1 mark

in its ground state?

# Exam model 15



# Open Book

#### Choose the correct answer for the questions (1): (2)





- Which of the following statements about the groups of the periodic table is correct?
  - (a) All groups contain metals and nonmetals.
  - (b) The elements in the same group have the same number of electrons.
  - © The chemical activity of the elements of group (1A) decreases by increasing the number of protons.
  - (d) H+ is easier to be separated from the halogen acids with increasing the atomic number of the halogen.
- All the following represent main transition elements, except .....
  - (a) 41Z
  - (b) Y: [Ar],  $4s^2$ ,  $3d^1$
  - © W: [Xe],  $6s^2$ ,  $4f^{14}$ ,  $5d^1$
  - (d) 110X
- Chlorine element forms 4 oxygenated acids, which are :

 $(HClO/HClO_2/HClO_4/HClO_3)$ 

What is the oxidation number of chlorine in the strongest acid?

(a) +7

(b) +5

(c) +3

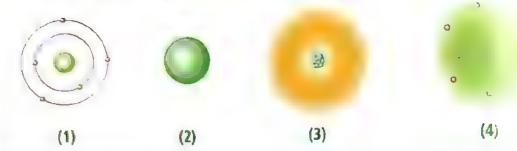
(d) +1

The opposite figure represents a section in the periodic table. Which of the following represents the electronegativity for these elements?

		33 ^{As}		
49 ^{In}	₅₀ Sn	51Sb	₅₂ Te	53 ^I
		"Bi		

Choices	The most electronegative element	The least electronegative element
(a)	As	Bi
<b>b</b>	I	In
0	I	Bi
<b>d</b>	Те	Sn





What is the correct historical order of these models?

What are the quantum numbers of the eighth electron in oxygen atom?

(a) 
$$n = 2$$
,  $l = 1$ ,  $m_l = -1$ ,  $m_s = -\frac{1}{2}$ 

(b) 
$$n = 2$$
,  $l = 1$ ,  $m_l = +1$ ,  $m_s = +\frac{1}{2}$ 

© 
$$n = 2$$
,  $l = 1$ ,  $m_l = +1$ ,  $m_s = -\frac{1}{2}$ 

(d) 
$$n = 2$$
,  $l = 0$ ,  $m_l = -1$ ,  $m_s = +\frac{1}{2}$ 

An element has the electron configuration : [Xe],  $4f^{14}$ ,  $5d^2$ ,  $6s^2$ 

What is the location of this element in the periodic table?

(a) Sixth period, group (1).

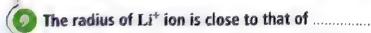
(b) Sixth period, group (2).

© Sixth period, group (4).

(d) Sixth period, group (17).

Each of the following determines the type of the element according to its electron configuration, except ......

Choices	Electron configuration	Type of the element
(3)	ns ^{1:2} or ns ² , np ⁶	Representative
6	$1s^2$ or $ns^2$ , $np^6$	Noble gas
©	$(n-1)d^{1:9}$ , $ns^{1}$ or 2	Main transition
(1)	$(n-2)f^{l:14}$ , $(n-1)d^{l \text{ or } 0}$ , $ns^2$	Inner transition



(a) Na+ ion.

(b) Be²⁺ ion.

© Mg²⁺ ion.

(d) Al3+ ion.

Mhich of the following processes is accompanied by releasing energy?

$$(a) Sc_{(g)} \longrightarrow Sc_{(g)}^+ + e^-$$

ⓑ 
$$F_{(g)} \longrightarrow F_{(g)}^+ + e^-$$

$$\bigcirc N_{(g)} - e^- \longrightarrow N_{(g)}^-$$

11 All the following oxides behave similarly during the chemical reactions,

except .....

(a) MgO

(b) SnO

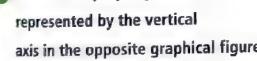
© ZnO

- (d) PbO
- Which of the following energy sublevels does not actually exist?
  - (a) 2p

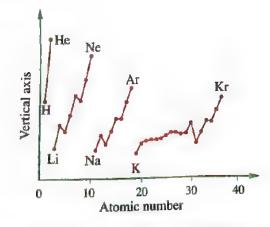
(b) 3d

(c) 5d

- (d) 3f
- B) What is the property which is represented by the vertical axis in the opposite graphical figure?



- (a) Atomic radius.
- (b) Electron affinity.
- © The first ionization potential.
- d Electronegativity.



Germanium Ge is located in the same group of carbon and silicon in the periodic table. Which of the following choices represents the correct formulae of the different compounds of germanium?

Choices	Germanium chloride	Germanium hydride	Germanium oxide
(a)	GeCl	GeH	GeO
Ь	GeCl	GeH ₄	${\rm GeO}_2$
©	GeCl ₄	GeH	GeO
(d)	GeCl ₄	GeH ₄	GeO ₂

# What is the change which happens when a phosphorus atom 15P is converted to a phosphide ion?

Choices	Number of unpaired electrons	Total number of electrons
a	Increases	Increases
Ъ	Decreases	Increases
0	Increases	Does not change
(1)	Decreases	Does not change

- How does the strength of the elements as reducing agents change through the third period from Na to Ar?
  - a Decreases regularly.

- (b) Increases regularly.
- © Decreases then increases.
- (d) Increases then decreases.
- What is the ascending graduation of the following elements in terms of the atomic radius ?
  - (a) Cs < Na < Mg < Ba

(b) Mg < Na < Ba < Cs

© Mg < Ba < Na < Cs

- (d) Ba < Mg < Na < Cs
- In which of the following elements the orbitals of 5d sublevel are occupied by electrons?
  - (a) 47Ag

(b) 56Ba

€ 63Eu

- (d) ₇₇Ir
- Which of the following transition of the electron of hydrogen atom produces visible light emission ?
  - (a)  $(n = 1) \longrightarrow (n = 2)$ .

(b)  $(n = 5) \longrightarrow (n = 2)$ .

©  $(n = 3) \longrightarrow (n = 4)$ .

- (d)  $(n = 3) \longrightarrow (n = 1)$ .
- Which of the following is among the conclusions of Rutherford's experiment?
  - Electrons revolve around the nucleus in definite orbitals.
  - (b) The mass and the positive charge of the atom are concentrated in its center.
  - The atoms of the same element are similar in mass.
  - d The electron is a particle with mass and has the properties of waves.

(21)

Use the following redox reaction to answer the question:

$$MnO_4^- + 5Fe^{2+} + 8H^+ \longrightarrow Mn^{2+} + 5Fe^{3+} + 4H_2O$$

During the reaction, electrons transfer from .....

(a)  $Fe^{3+} \longrightarrow Fe^{2+}$ 

ⓑ  $Fe^{2+}$  →  $MnO_4^-$ 

© MnO₄ — Fe²⁺

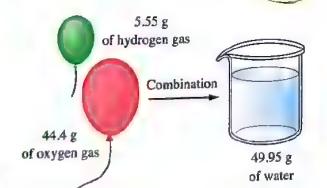
- The following table illustrates the ionization potentials (from the fifth to the eighth) of two elements (X) and (Y) in the third period in the periodic table:

-1	ionization potentials (k.J/mol)							
Element	Fifth	Sixth	Seventh	Eighth				
(X)	+7012	+8496	+27107	+31671				
(Y)	+6542	+9362	+11018	+33606				

(1) What is the number of the group of element (Y) ? Explain.

.....

(2) Write the electronic configuration of the element (X) according to aufbau principle.



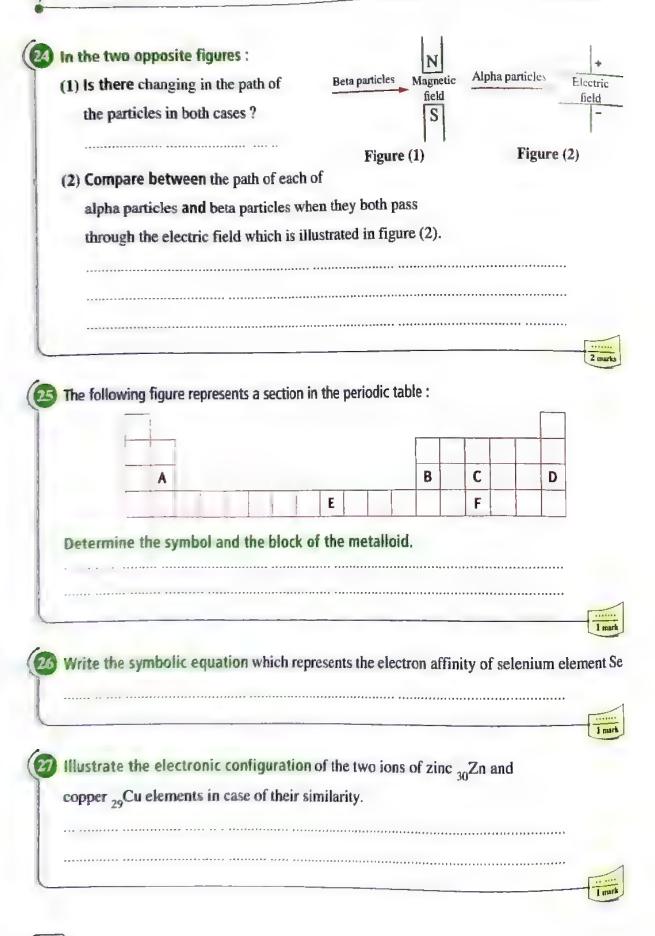
- The opposite figure represents one of the postulates of an atomic theory that you studied :
  - (1) What is the name of this theory?

(2) State the postulate which is represented in the figure

٠.	 -14

2 marks

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# Answers of Chapter lesson One

### **Answers of multiple choice questions**

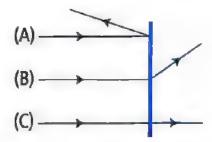
Question number	1	2	3	4	5	6	7	8	9	10
Answer	d	С	a	a	a	d	d	d	d	d
Question number	11	12	13	14	15	16	17	18	19	20
Answer	d	d	a	d	d	ь	b	d	c	d
Question number	21	22	23	24	25	26	27	28	29	30
Answer	С	d	d	d	С	d	a	С	С	c
Question number	31	32	33	34	35	36	37	38		
Answer	a	a	c	d	С	b	С	a		

# **Answers** of essay questions

- (1) So that the gas can conduct the electricity, as gases do not conduct electricity under normal conditions of pressure and temperature.
  - (2) Because they are streams of invisible rays emitted from the cathode of the discharge tube.
  - (3) Because alpha particles are positively charged, while electrons are negatively charged.
  - (4) To detect the invisible alpha particles, as they glow at the positions where they collide with this substance (ZnS).



- (5) As he believed that the atom is composed of a central nucleus (representing the sun), and the electrons revolve around it (representing the planets).
- (6) Because the attraction forces between the electron and the nucleus equate the centrifugal force on the electron resulting from its continuous revolution around the nucleus.
- No cathode rays would be emitted / As the gases do not conduct electricity under normal conditions of pressure and temperature.
- Cathode rays are not affected / As cathode rays do not vary with the nature of the cathode material, or the used gas.
- (1) Due to the presence of a tiny part of a very high density, which was named by the nucleus.
  - (2) (i) Most of the atomic volume is an empty space.
    - (ii) The charge of the nucleus is similar to that of alpha particles, so the particles are repelled on approaching the nucleus.
- Particles (B) / As they pass in the spaces of the atom.
- **44** (1)



(2) To find out the ratio between the numbers of penetrating, reflected and the deflected alpha particles to identify the atomic structure on trial basis.

# (Answers of the higher-order questions)

Question number	Answer	Idea of answering
45	C	Among Dalton's postulates are:  * The masses of the atoms of the same element are similar.  ∴ The choice (a) is excluded.  * The masses of the atoms differ from one element to another.  ∴ The choice (b) is excluded.  * The element atom is indivisible (can not undergo
		fission process).  The correct choice is ©

#### (1) Dalton.

(2) The compounds are formed by the combination of the elements atoms in simple numerical ratios.

# Answers of Chapter lesson Two

### **Answers of multiple choice questions**

Question number	1	2	3	4	5	6	7	8	9	10
Answer	b	a	b	a	d	b	b	С	С	c
Question number	11	12	13	14	15	16	17	18	19	20
Answer	b	С	С	a	a	a	b	a	С	d
Question number	21	22	23	24	25	26	27	28	29	30
Answer	d	c	c	b	c	b	b	a	С	c

Question number	31	32	33	34	35	36	37	38
Answer	С	С	С	a	С	b	b	a

# **Answers of essay questions**

- (1) As it is composed of a limited number of restricted coloured lines separated by dark areas.
  - (2) Because there are no two elements with the same line spectrum.
  - (3) Because the distance and the difference in energy between the different energy levels are not equal.
  - (4) As it was proved later that the hydrogen atom has three dimensional coordinates.
  - (5) As it is a material particle which also has wave properties.
- Position © / Because the spaces between the energy levels are forbidden for the electrons.
  - Position 🔘 / Because the electron revolves in the energy levels around the nucleus and not inside the nucleus.

- The energy of the electron increases and it transfers from its stable energy level to a higher energy level (farther from the nucleus).
- B / Because the visible spectrum is formed of the emission of quanta when the excited electron travels from the energy levels which are higher than (n = 2) to the energy level (n = 2) only.
- Figure (2) / Because the wavelength of the green light is lower than that of the red light.
- 46 (1) Bohr.

(2) Electron cloud.

# **(Answers of the higher-order questions)**

Question number	Answer	Idea of answering
<b>47</b>	0	<ul> <li>∴ Red light has the highest wavelength, and hence the lowest frequency (in the visible spectrum).</li> <li>∴ The correct choice is c</li> </ul>
48	a	According to Bohr's model, the electron orbits the nucleus in a definite specific orbit.  (i.e. there is one constant probability for the presence of the electron at a certain distance from the nucleus).  .: The correct choice is a
49	Ь	<ul> <li>∴ The wavelength of the photon is 486 nm</li> <li>∴ The photon lies in the wavelength band of the visible spectrum (410:656 nm).</li> <li>∴ The visible spectrum of hydrogen atom is produced by the transfer of the excited electron from energy levels higher than (n = 2) to the second energy level only.</li> <li>∴ The correct choice is b</li> </ul>
50	Ь	<ul> <li>∴ The difference in energy between each energy level and the level which follows it decreases by increasing the distance from the nucleus.</li> <li>∴ ΔE₂ &lt; ΔE₁</li> <li>∴ The correct choice is (b)</li> </ul>



<b>5</b>	C	To transfer from energy level L to K. the electron must love a quantum of energy.  The choices b and d are excluded.  The difference in energy between the two levels (K and L) is higher than that between (L and M).  The choice a is excluded.  The correct choice is c
52	C	If the electron acquires a certain amount of energy, it can transfer to a higher energy level only when this amount of energy equals the difference in energy between these two levels (a quantum).  The difference in energy between the levels M and N (ΔE) = (-1 × 10 ⁻¹⁹ ) - (-5 × 10 ⁻¹⁹ ) = 4 × 10 ⁻¹⁹ J
		<ul> <li>∴ The gained energy (4 × 10⁻¹⁹ J) equals the difference in energy between the two levels M and N</li> <li>∴ The electron will travel to the energy level N</li> <li>∴ The correct choice is c</li> </ul>

53 The frequency of the red light, as the wavelength of the red light is less than that of the infrared radiation, and the frequency is inversely proportional to the wavelength.

# Answers of Chapter lesson Three

# **Answers of multiple choice questions**

Question number	1	2	3	4	5	6	7	8	9	10
Answer	c	c	a	d	b	b	b	С	a	d
Cuartan and	11	12	13	14	15	16	17	18	19	20
Question number	Y Y	1.2								

9

Question number					25	26	27	28	29	30
Arrawar	a	d	c	d		c		c	c	d
Question number	31	32	33	34	35		<b></b>			
Anower	d	c	b	a	c	•				

### Answers of essay questions

- (1) Values of (/): 0, 1, 2, 3
  - (2) Values of  $(m_p)$ : -3, -2, -1, 0, +1, +2, +3
- Sumber of electrons in the principal level  $(n = 2) = 2n^2 = 8$  electrons. Number of electrons in the sublevel  $4d = 2 \times 5 = 10$  electrons.

The maximum number of electrons in 4d sublevel is higher than that in the principal level (n = 2).

- with the second point  $n^2 = n^2 =$
- **G** 5

0

- Butterel
- -3 -2 -1 0 +1 +2 +3
- Subtraced of
- 21-10-11-2
- Satisfievel p
- 1,0,01

butturvei 4

- 4
- (1) because the possitive values of (f) as the principal level in = 1; when  $(m_f = +2)$  is 2 only.
  - (2) Because the possible values of (m_j) as the subsevel (l = 1) are -1, 0, +1 only.
  - (3) Because im, values are anteger manibers only whether positive on negative, and the possible value of tem,) of the sublevel ( = fit is only the



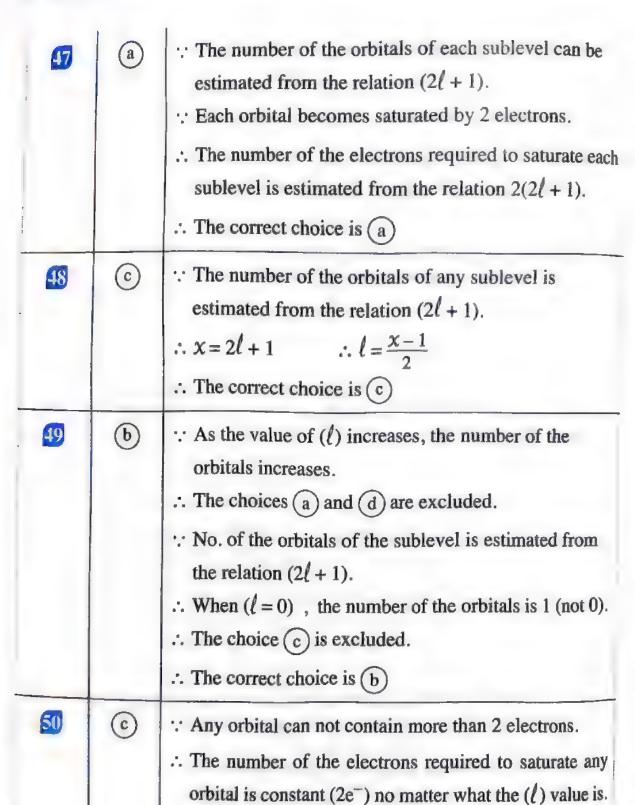
Orbital	(m _ℓ )	(1)	(n)
$2p_{_X}$	-1	1	2
1s	0	0	1
4f	+3	3	4
4p _y	0	1	4
3d	-2	2	3

### $44 * Figure (2) / 3p_y$

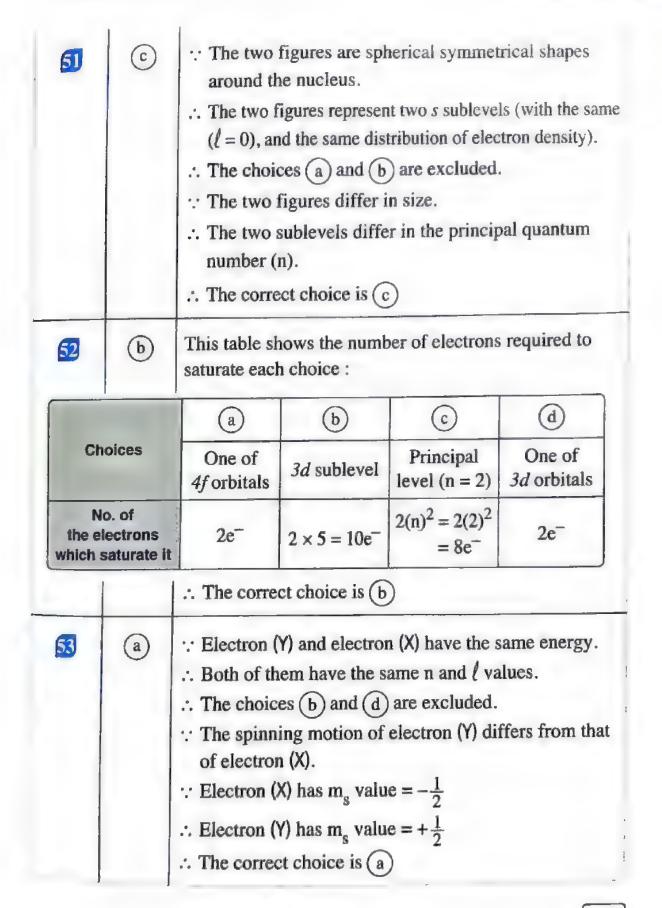
* Figure (3) / 2p_y

# **Answers of the higher-order questions**

Question number	Answer	Idea of answering
45	Ъ	<ul> <li>∴ n = 4 , l = 1</li> <li>∴ The sublevel is 4p</li> <li>∴ Each p sublevel consists of 3 orbitals, and each orbital becomes saturated by 2 electrons.</li> <li>∴ The maximum number of electrons = 3 × 2 = 6e</li> <li>∴ The correct choice is b</li> </ul>
46	©	∴ $l = 3$ ∴ The sublevel is $f$ sublevel. ∴ The sublevel $f$ consists of 7 orbitals, each of them becomes filled with 2 electrons, one of them spins clockwise (†) and its $m_s = +\frac{1}{2}$ , and the other spins anticlockwise (†) and its $m_s = -\frac{1}{2}$ ∴ The maximum number of electrons which have $(m_s = +\frac{1}{2}) = 7e^-$ ∴ The correct choice is $(c)$



.. The correct choice is (c)



- 54 (1) Number of electrons =  $2n^2 = 2 \times 3^2 = 18$  electrons.
  - (2) Number of electrons = Number of electrons of 2s sublevel = 2 electrons.

# Answers of Chapter Lesson Four

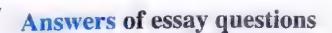
### **Answers of multiple choice questions**

Question number	1	2	3	4	5	6	7	8	9	10
Answer	d	d	b	a	b	a	b	b	b	a

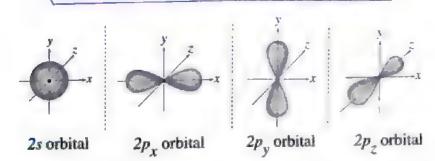
Question number	11	12	13	14	15	16	17	18	19	20
Answer	d	b	С	d	b	d	a	С	С	b

Question number	21	22	23	24	25	26	27	28	29	30
Answer	a	С	С	b	b	b	b	С	a	d

Question number	31	32	33	34	35	36	37
Answer	c	c	С	d	b	b	С







- The two electrons have the same principal quantum number (n = 2), subsidiary quantum number  $(\ell = 1)$ , and the magnetic quantum number  $(m_{\ell})$ .

  They may differ in the spin quantum number  $(m_{s})$ .  $m_{s} = +\frac{1}{2}$  or  $-\frac{1}{2}$
- $40_{17}$ CT:  $1s^2$ ,  $2s^2$ ,  $2p^6$ ,  $3s^2$ ,  $3p^6$ 
  - * The last two electrons have the same (n), (l), (m) but they differ in (ms).

Quantum numbers	(n)	(1)	(m _ℓ )	(m _s )
First electron	3	1	+1	$+\frac{1}{2}$
Second electron	3	1	+1	$-\frac{1}{2}$

- (1) Pauli's principle is not applied due to the presence of two electrons with the same four quantum numbers in the first orbital of p sublevel.
  - Hund's rule is applied where the pairing of the electrons did not happen before all orbitals were occupied with unpaired electrons first.
  - (2) Pauli's principle is applied as there are no two electrons have the same four quantum numbers.
    - Hund's rule is applied where the pairing did not happen before all orbitals were occupied with unpaired electrons first.

- The last electron is found in the third orbital of 2p sublevel.
  - .. The electronic configuration of the element is:

$$1s^2, 2s^2, 2p^3$$

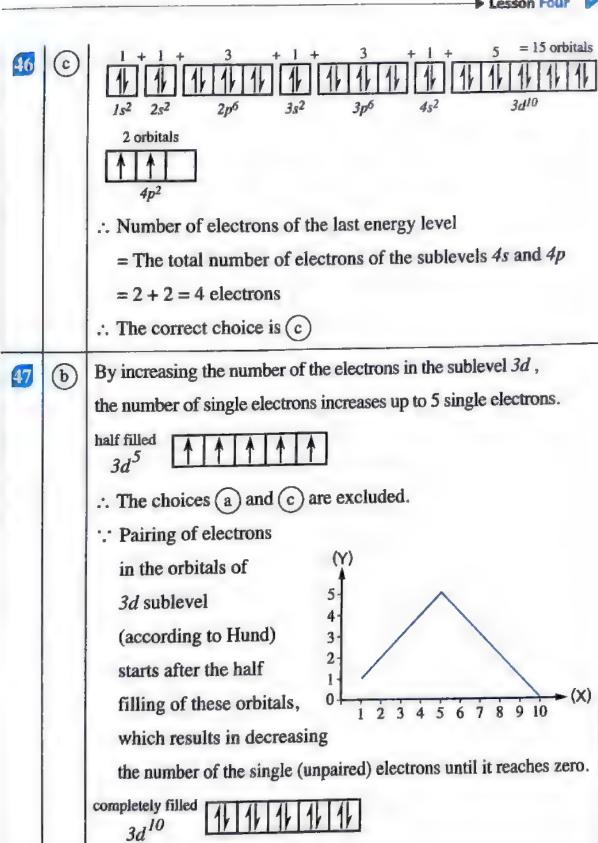
- $\therefore$  The atomic number = 7
- 43 (1)  $1s^2$ ,  $2s^2$ ,  $2p^6$ ,  $3s^2$ ,  $3p^6$ ,  $4s^2$ ,  $3d^5$ 
  - .. Maximum number of electrons = 25 electrons.
  - (2)  $1s^2$ ,  $2s^2$ ,  $2p^6$ ,  $3s^2$ ,  $3p^6$ ,  $4s^2$ ,  $3d^{10}$ ,  $4p^6$ ,  $5s^2$ ,  $4d^{10}$ ,  $5p^6$ ,  $6s^2$ ,  $4f^{14}$ 
    - :. Maximum number of electrons = 70 electrons.
- (1): The electronic configuration of the atom of the element (x) is:

$$1s^2$$
,  $2s^2$ ,  $2p^6$ ,  $3s^2$ ,  $3p^6$ ,  $4s^2$ ,  $3d^{10}$ ,  $4p^2$ 

$$n=4$$
,  $l=1$ ,  $m_1=0$ ,  $m_s=+\frac{1}{2}$ 

# (Answers of the higher-order questions)

Question number	Answer	Idea of answering
45	©	The two electrons of the same $(m_{\ell})$ $-1$ $0$ $+1$ sublevel which have the same $np$ $\uparrow$
		<ul> <li>∴ The two electrons differ in the magnetic quantum number m_ℓ only.</li> <li>∴ The correct choice is c</li> </ul>



:. The correct choice is (b)

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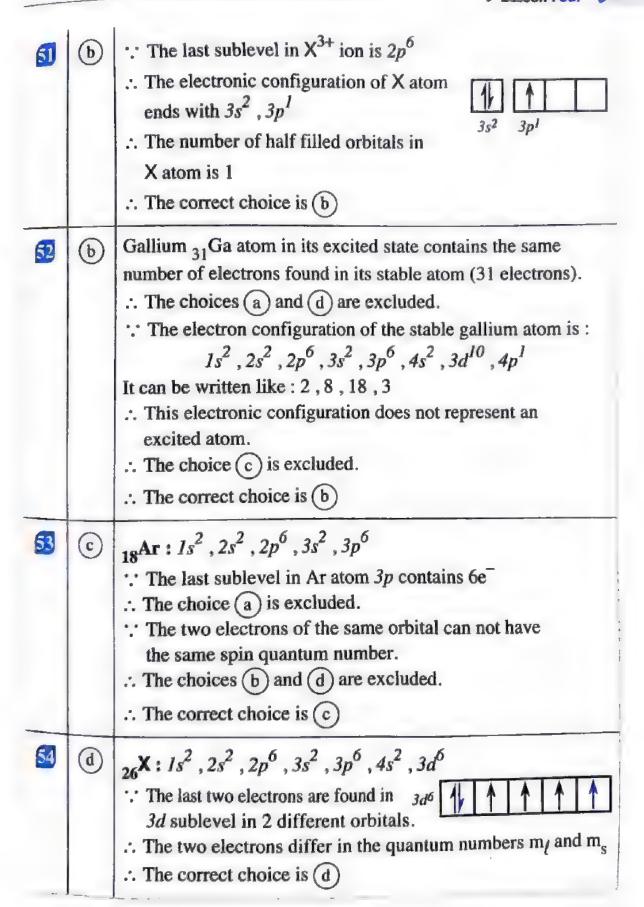
48	Ь	The sublevel which consists of 3 orbitals is $p$ $ \therefore \ell = 1 $ $ \because n + \ell = 5 $ $ \therefore n = 4 $ $ \therefore \text{ The last sublevel in this element atom is } 4p^{\ell} $ $ \therefore \text{ The electron configuration of this element atom is :} $ $ 1s^{2}, 2s^{2}, 2p^{6}, 3s^{2}, 3p^{6}, 4s^{2}, 3d^{\ell 0}, 4p^{\ell} $ $ \therefore \text{ The atomic number of this element } = 31 $ $ \therefore \text{ The correct choice is } \boxed{b} $
49	0	<ul> <li>∴ The principal quantum number of the farthest electron from the nucleus n = 4</li> <li>∴ The farthest electron is found in the 4th principal energy level.</li> <li>∴ No. of electrons in the level M is double that in level L (16e)</li> <li>∴ The electronic configuration of the atom of this element is:</li> <li>1s², 2s², 2p6, 3s², 3p6, 4s², 3d8</li> <li>∴ The atomic number of element (x) = 28</li> <li>∴ The correct choice is €</li> </ul>
50	Ь	∴ Element (X) atom contains 3 occupied principal levels, and the summation of the spin quantum numbers of its valence electrons is $1\frac{1}{2}$ ∴ Its electron configurations is : $1s^2$ , $2s^2$ , $2p^6$ , $3s^2$ , $3p^3$ Summation of $m_s \left( +\frac{1}{2} - \frac{1}{2} \right) \left( +\frac{1}{2} + \frac{1}{2} + \frac{1}{2} \right)$ of valence electrons = $0$ = $1\frac{1}{2}$ ∴ The atomic number of (X) = 15

:. The correct choice is (b)

<b>a</b>	Ъ	<ul> <li>∴ The last sublevel in</li> <li>∴ The electronic configends with 3s², 3p¹</li> <li>∴ The number of half in X atom is 1</li> <li>∴ The correct choice in</li> </ul>
82	Ь	Gallium 31Ga atom into number of electrons for .: The choices (a) and .: The electron configure 1s², 2s², 2; It can be written like: .: This electronic configure excited atom: The choice (c) is each .: The correct choice
<b>33</b>	0	18Ar: 1s ² , 2s ² , 2p ⁶ ,  ∴ The last sublevel in ∴ The choice (a) is es ∴ The two electrons of the same spin quan ∴ The choices (b) and ∴ The correct choice :
54	<b>a</b>	$26$ <b>X</b> : $1s^2$ , $2s^2$ , $2p^6$ , $3$ The last two electron

3d sublevel in 2 dif
∴ The two electrons d

.. The correct choice:



# Answers of the exam model of chapter

# **Answers of multiple choice questions**

Question number	1	2	3	4	5	6	7	8	9	10
Answer	a	d	b	С	d	b	d	a	b	b

Question number	11	12	13	14	15	16	17	18	19	20
Answer	С	a	С	b	b	С	d	С	a	b

# **Answers of essay questions**

- The electrons: Are deflected towards the positive electrode / As they are negatively charged.
  - The protons: Are deflected towards the negative electrode / As they are positively charged.
  - The neutrons: Are not deflected / As they are neutral.

Atomic model	Thomson's	Rutherford's
Atom	* Solid sphere of uniform positive electric charges in which a number of negatively charged electrons are embedded resulting in making the atom neutral.	* Contains a vast space (not solid).  * Electrically neutral.



#### **Electrons**

* Negatively charged particles embedded in the atom.

- * Negatively charged particles, and their total negative charge equals the positive charge of the nucleus.
- * They move around the nucleus at tremendous speeds in special orbits.
- * Their mass is negligible compared to that of the nucleus.

- * The Process: (X).
  - * The scientific name: The quantum.

# Answers of Chapter 2 lesson One

# **Answers of multiple choice questions**

Question number	1	2	3	4	5	6	7	8	9	10
Answer	С	d	С	С	b	d	b	a	b	a
Question number	11	12	13	14	15	16	17	18	19	20
Answer	c	d	С	С	d	d	a	С	С	c
Question number	21	22	23	24	25	26	27	28	29	30
Answer	a	d	a	b	a	С	b	b	b	d

Question number	31	32	33	34	35	36	37	38	39	40
Answer	d	b	d	c	С	d	a	С	c	d

Question number	41	42	43	44	45	46	47	48	49
Answer	a	b	d	d	a	b	d	a	c

### **Answers of essay questions**

- (1) Because they have similar electronic configurations for their outermost energy levels (valence shells).
  - (2)  $_{42}$ MO: [Kr],  $5s^2$ ,  $4d^4$

As the atom becomes more stable when 4d sublevel is half filled with electrons.

- $51_{29}$ Cu⁺ ion and  $_{30}$ Zn²⁺ ion have similar electronic configuration: [Ar],  $3d^{10}$
- 52 It is obvious in the figure that the first period is not present, consequently:
  - Element (T) is located in the fourth period, group (2A), so its electronic configuration is [Ar],  $4s^2$ 
    - $\therefore$  The atomic number of (T) = 18 + 2 = 20
  - Element (U) is located in the fifth period, group 7 (7B), so its electronic configuration is [Kr],  $5s^2$ ,  $4d^5$ 
    - $\therefore$  The atomic number of (U) = 36 + 2 + 5 = 43

The difference between their atomic numbers = 43 - 20 = 23

- 53 (1) Main transition element.
  - (2) : The electronic configuration of the element ends with :  $5s^2$ ,  $4d^1$ 
    - ... The element lies in 5th period, group 3B (3).



- (3) : The element lies in 5th period.
  - .. Its electronic configuration begins with the noble gas found in 4th period which is krypton 36Kr
  - : Its full electronic configuration is : [Kr],  $5s^2$ ,  $4d^1$
  - .. Number of protons = Atomic number = 36 + 2 + 1 = 39
  - .. Number of protons in the nucleus of this element atom = 39 protons.
- 54 (1) * The electronic configuration :  $1s^2$ ,  $2s^2$ ,  $2p^3$ 
  - * Location: The second period, group 5A (15).
  - (2) p-block.

55		Block	Туре
	(1)	d	Main transition
	(2)	f	Inner transition

56 Element		Electronic configuration	Atomic number
	(1)	[He], $2s^2$ , $2p^3$	7
	(2)	[Ne], $3s^2$ , $3p^6$	18

- 57 (1) [He],  $2s^2$ ,  $2p^1$ 
  - (2) Period: Second.
- Group: 13 (3A).
- Element 7W electronic configuration is : [He],  $2s^2$ ,  $2p^3$ 
  - ∴ It is located in the second period, group 5A (15).

    Consequently element X is located in the third period, group 4A (14), and its electronic configuration: [Ne], 3s², 3p²
    - $\therefore$  The atomic number of X = 10 + 2 + 2 = 14
- The metals of group 2A tend to lose their valence electrons during the chemical reactions, forming M²⁺ ion.
  - .. The general formula of their oxides: MO

# (Answers of the higher-order questions)

Question number	Answer	Idea of answering
60	(0)	<ul> <li>By increasing the atomic numbers of the elements down the same vertical group in the periodic table, the number of the principal energy levels which are occupied by electrons increases.</li> <li>The choices b and d are excluded.</li> <li>The increase in the atomic number on moving from one period to another in the same group is not regular (does not have a pattern).</li> <li>The choice a is excluded.</li> <li>The correct choice is c</li> </ul>
61	©	The following table shows the electronic configurations of the atoms and the ions of the compounds mentioned in the choices and the number of the electrons in each of them:

Electronic configuration of the element atom	Electronic configuration of its ion	No. of electrons in the ion
$_{12}$ Mg: $1s^2$ , $2s^2$ , $2p^6$ , $3s^2$	$Mg^{2+}: 1s^2, 2s^2, 2p^6$	10
$_{17}\text{Cl}: 1s^2, 2s^2, 2p^6, 3s^2, 3p^5$	$CI^-: 1s^2, 2s^2, 2p^6, 3s^2, 3p^6$	18
$_{11}$ Na: $1s^2$ , $2s^2$ , $2p^6$ , $3s^1$	$Na^+: 1s^2, 2s^2, 2p^6$	10
$_{8}O: 1s^{2}, 2s^{2}, 2p^{4}$	$0^{2-}: 1s^2, 2s^2, 2p^6$	10
$16$ S: $1s^2$ , $2s^2$ , $2p^6$ , $3s^2$ , $3p^4$	$S^{2-}: 1s^2, 2s^2, 2p^6, 3s^2, 3p^6$	18

- : No. of Mg²⁺ electrons ≠ No. of Cl electrons.
- ∴ The choice (a) is excluded.
  ∴ No. of Na⁺ electrons ≠ No. of Cl⁻ electrons.
- .. The choice (b) is excluded.
- : No. of  $Mg^{2+}$  electrons = No. of  $O^{2-}$  electrons.
- :. The correct choice is (c)



- : Element (X) forms the compounds XCl₃, X₂O₃
  - :. Element (X) is trivalent.
  - ... The electronic configuration of element (X) ends with  $ns^2$ ,  $np^3$
  - :. Element (X) is located in group (III A).
  - :. The correct choice is (a)



- The positive ion of the compound MO is divalent and its electronic configuration ends with  $2p^6$
- .. The electronic configuration of element M is:  $1s^2$ ,  $2s^2$ ,  $2p^6$ ,  $3s^2$
- :. Element M lies in 3rd period, group 2
- .. The correct choice is (d)



: The 4 quantum numbers of the last electron which has the highest energy in the atom of the transition element are:

$$n = 3$$
,  $\ell = 2$ ,  $m_{\ell} = +2$ ,  $m_{s} = +\frac{1}{2}$ 

- ... The electron with the highest energy exists in the sublevel 3d5
- .. The electron configuration of this element atom is: [Ar],  $4s^2$ ,  $3d^5$
- : The electron configuration of the last representative element in the same period of this transition element is: [Ar],  $4s^2$ ,  $3d^{10}$ ,  $4p^5$ ,
- .. The quantum numbers of the last electron in this representative element are:

$$n = 4$$
,  $\ell = 1$ ,  $m_{\ell} = 0$ ,  $m_{s} = -\frac{1}{2}$ 

.. The correct choice is (a)

## Answers of Chapter 2 lesson Two

### **Answers of multiple choice questions**

Question number	1	2	3	4	5	6	7	8	9	10
Answer	d	b	a	b	d	a	d	d	С	b

Question number	11	12	13	14	15	16	17	18	19	20
Answer	С	a	b	a	a	b	d	b	a	b

Question number	21	22	23	24	25	26	27	28	29	30
Answer	a	a	d	a	a	С	d	b	b	d

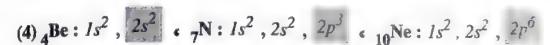
Question number	31	32	33	34	35	36
Answer	d	b	b	b	b	d

### **Answers of essay questions**

- (1) Because it is impossible to determine the precise location of the electron around the nucleus.
  - (2)  $_{15}P: [Ne], 3s^2, 3p^3$   $_{16}S: [Ne], 3s^2, 3p^4$

Because the atom is more stable when sublevel 3p is half filled with electrons (as in phosphorus), and hence removing an electron decreases its stability.

(3) Because it requires breaking a completely filled energy level.



Because the atom will be more stable when the sublevel:

- 2s is completely filled as in case of beryllium atom 4Be
- 2p is half filled as in case of nitrogen atom 7N
- 2p is completely filled as in case of neon atom 10 Ne and the addition of an electron to any of these atoms decreases its stability.
- (5) Because fluorine atom is smaller in size as it has smaller radius than chlorine atom, so any new electron will suffer a strong repulsive force with the nine electrons already existing around the fluorine nucleus which decreases the released energy due to consuming a part of this energy to overcome this repulsive force.

The atomic radius of oxygen = 
$$\frac{\text{Bond length in O}_2 \text{ molecule}}{2}$$
  
 $\therefore \text{ r (O)} = \frac{1.32}{2} = 0.66 \text{ Å}$ 

The atomic radius of hydrogen =

(O - H) bond length - The atomic radius of oxygen

$$\therefore$$
 r (H) = 0.96 – 0.66 = 0.3 Å

39 The atomic radius of hydrogen =

(H - Cl) bond length - The atomic radius of chlorine

$$\therefore$$
 r (H) = 1.29 – 0.99 = 0.3 Å  $\therefore$  2r (H₂) = 2 × 0.3 = 0.6 Å

$$\therefore 2r (H_2) = 2 \times 0.3 = 0.6 \text{ Å}$$

The atomic radius of nitrogen =

(N – H) bond length – The atomic radius of hydrogen

$$r(N) = 1 - 0.3 = 0.7 \text{ Å}$$

$$\therefore 2r(N_2) = 2 \times 0.7 = 1.4 \text{ Å}$$

.. The bond length of nitrogen molecule (1.4 Å) is longer than that of hydrogen molecule (0.6 Å).

As it is an ionic compound.

(2) The bond length in HBr molecule = 
$$r(H) + r(Br)$$
  
=  $0.3 + 1.14 = 1.44 \text{ Å}$ 

As it is a covalent compound.

- (1) 20Ca > 12Mg > 17Cl / As the radius increases in the same group by increasing the atomic number and decreases in the same period by increasing the atomic number.
  - (2)  $L_2 > Br_2 > Cl_2 > F_2$  / As the radius, and the bond length subsequently, increase in the same group by increasing the atomic number.
- 42 The statements (2) and (3).
- (1) Because the increase in the number of the negative electrons more than the number of the positive protons in sulphide anion increases the repulsion forces between the electrons, leading to increasing the size of the anion.
  - (2) Because the number of positive protons in Ca²⁺ is higher than the number of positive protons in S²⁻, consequently the effective nuclear charge in Ca²⁺ is higher, so this causes the radius to decrease.
- 24 : Its 6th ionization potential is very high compared to the 5th ionization potential.
  - .. Removing the 6th electron requires breaking a completely filled level, consequently this element has 5 electrons in its valence shell.
  - : It is located in the third period.
  - :. Its electronic configuration is :  $1s^2$ ,  $2s^2$ ,  $2p^6$ ,  $3s^2$ ,  $3p^3$



(2) M⁺ is larger in radius, as the ionic radius of the positive ion decreases by increasing its positive charge.

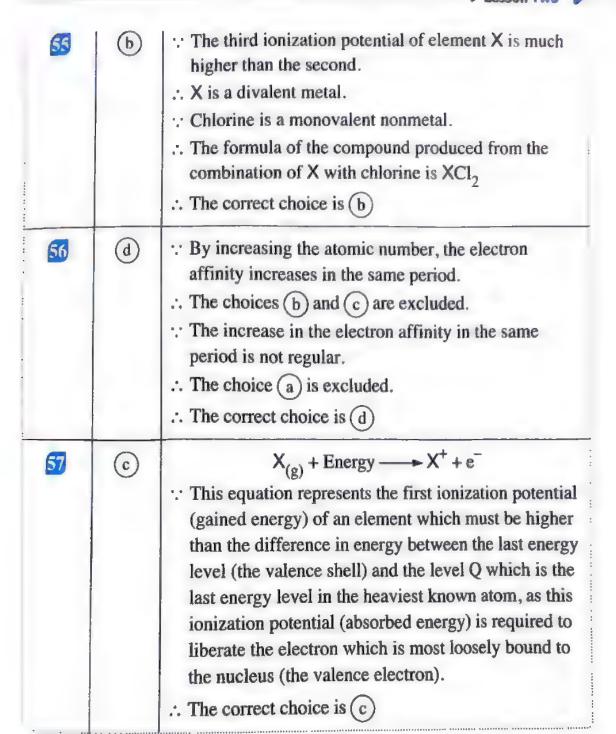
$$Ti_{(g)}^{2+} + Energy \longrightarrow Ti_{(g)}^{3+} + e^-$$
,  $\Delta H = (+)$ 

- First ionization potential of sodium Na_(g) and the electron affinity of chlorine Cl_(g)
- As the ionic radius of the negative ion is larger than its atomic radius, and the radius increases in the same group by increasing the atomic number.

### **Answers of the higher-order questions**

Question number	Answer	Idea of answering
<u>50</u>	<b>d</b>	<ul> <li>The atomic radius of an element of group 1A is larger than its ionic radius.</li> <li>The ratio between them is greater than 1</li> <li>The correct choice is d</li> </ul>
51	©	<ul> <li>∴ Ionic radius of M²⁺ &gt; Ionic radius of M³⁺         &gt; Ionic radius of M⁴⁺         As, the ionic radius of the positive ion decreases as its charge value increases.         ∴ The correct order of the oxides according to the bond length is: MO₂ &lt; M₂O₃ &lt; MO         ∴ The correct choice is ©     </li> </ul>

52	C	The 4 quantum numbers	n	1	m,	m
		show that the last electron			-	m _s
		in this element atom	4	3	0	$+\frac{1}{2}$
6.		exists in the sublevel $4f$ ,				
0 0 0 0 0		consequently, element (X) is				
*		located in the 6 th period.				
* * * * * * * * * * * * * * * * * * *		: Element (Y) is located in the	same	period	of (X)	and
		has the largest atomic size.	th			
· · · · · · · · · · · · · · · · · · ·		:. Element (Y) is located in the			_	
6 T		: The electronic configuration				h is:
4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4		[Xe], $6s^I$ shows that its atom	mic nui	mber is	5 55	
		: The correct choice is (c)				
53	a	: The atomic number of elements		is less	than b	oth
40 65 67 68 68 68 68 68		atomic numbers of (Y) and (				
표 전 전 선 선 선 선 선		: The choices b and c are				
		: The electron configurations o	f carbo	n and r	utrogen	are:
•		$_{6}$ C: $1s^{2}$ , $2s^{2}$ , $2p^{2}$				1
		$_{7}$ N: $Is^2, 2s^2, 2p^3$				1
		The atom of 7N is more stab	le than	that o	f ₆ C, a	s its
		2p sublevel is half filled wit			-	-
		an electron from this half fil				1
		stability, hence its ionization	poten	tial is	higher.	
		:. The correct choice is (a)				
54	<b>©</b>	$_{13}AI : [Ne], 3s^2, 3p^1$				
		: The valence shell of aluming	ım con	tains 3	electro	ons.
		The fourth ionization potent				
4 A A A A A A A A A A A A A A A A A A A		higher than the third.				100000
P ***		:. The correct choice is (c)				1



- (1) Number of electrons in chromium ion  $Cr^{2+}$  in CrO = 22 electrons.
  - Number of electrons in chromium ion  $Cr^{3+}$  in  $Cr_2O_3 = 21$  electrons.
  - (2) The bond length in the formula unit of chromium (II) oxide is longer/As its ionic radius increases by decreasing the positive charge, hence the bond length increases.

### Answers of Chapter 2 lesson Three

### **Answers of multiple choice questions**

Question number	1	2	3	4	5	6	7	8	9	10
Answer	a	С	b	a	a	b	С	a	b	a

Question number	11	12	13	14	15	16	17	18	19	20
Answer	b	С	d	d	d	d	d	С	a	С

Question number	21	22	23	24	25	26
Answer	d	a	a	d	a	b

### **Answers of essay questions**

$$(1) SO_{3(g)} + H_2O_{(l)} \longrightarrow H_2SO_{4(aq)}$$

$$(2) CO_{2(g)} + H_2O_{(l)} \longrightarrow H_2CO_{3(aq)}$$

(3) 
$$K_2O_{(s)} + H_2O_{(t)} \longrightarrow 2KOH_{(aq)}$$

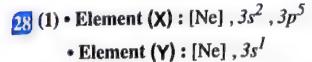
(4) 
$$Na_2O_{(s)} + H_2O_{(l)} \longrightarrow 2NaOH_{(aq)}$$

$$(or)$$
 Na₂O_(s) + 2HCl_(aq)  $\longrightarrow$  2NaCl_(aq) + H₂O_(l)

(5) 
$$Na_2O_{(s)} + 2HCl_{(aq)} \longrightarrow 2NaCl_{(aq)} + H_2O_{(l)}$$

(6) 
$$ZnO_{(s)} + H_2SO_{4(aq)} \longrightarrow ZnSO_{4(aq)} + H_2O_{(l)}$$

$$ZnO_{(s)} + 2NaOH_{(aq)} \longrightarrow Na_2ZnO_{2(aq)} + H_2O_{(l)}$$



(2) Element (Y) / As it is a metal, which tends to lose the electron of its valence shell forming a positive ion with the same electronic configuration of the nearest noble gas that precedes it in the periodic table.

(1) 
$$Al_2O_3 + 2NaOH \longrightarrow 2NaAlO_2 + H_2O$$
  
(2)  $Al_2O_3 + 3H_2SO_4 \longrightarrow Al_2(SO_4)_3 + 3H_2O$ 

- 30 As (O H) bond is stronger than (Cs O) bond in cesium hydroxide, while (Cl = O) bond is stronger than (O - H) bond in  $ClO_3(OH)$ .
- (1) 3 atoms.
  - (2) As when it dissolves in water, it yields a basic solution.

### (Answers of the higher-order questions)

Question number	Answer	Idea of answering
32	d	It is obvious in the chart that the ionization potentials of the two elements (X) and (Z) are relatively high.  ∴ The choices (a) and (c) are excluded.  ∴ The electron configurations of the atoms of the two elements (Y) and (W) are:  3Y: [He], 2s ^I 11W: [Ne], 3s ^I This shows that element (W) follows element (Y) directly in their group (1A).  ∴ The atom of element (W) loses its valence electron easier than the atom of element (Y).  ∴ The correct choice is (d)

33	©	∴ One of the Na ₂ O and P ₂ O ₅ are ∴ The choice ∴ The two	ese oxides I MgO are lacidic oxides oxides are oxides a	lution. is acidic a basic oxid les. d are ex of element in the secon	nd the others, while Sacluded.	er is basic. $SO_3$ and	
34	©	the last p	own in the olded that this ctrons in the s.  Sable electrons	opposite for selement se formation onic configured in M at	gure,	О О О	<b>H</b> .
35	(d)	The following anion and it	-		kygenated a	cid of each	
		Negative radical	so ₄ ² -	ClO ₂	ClO ₃	ClO ₄	
		Oxygenated acid	H ₂ SO ₄	HClO ₂	HClO ₃	HClO ₄	* * * * * * * * * * * * * * * * * * * *
		Hydroxy formula	ClO ₃ (OH)	:			
		increasin ∴ HClO ₄ i		oms nonbi	•	ises by drogen in it.	***************************************





- : (O-H) bond is stronger than (O-M) bond.
- ∴ The compound is being ionized as a base.
  ∴ M⁺ ion is an ion of a metal of s-block.
- ... The correct choice is (a)

#### *(X/Mg),(Y/K),(Z/Al)

* The order of the elements according to the metallic property is: (K > Mg > Al)

#### Answers of Chapter lesson Four

### **Answers of multiple choice questions**

Question number	1	2	3	4	5	6	7	8	9	10
Answer	a	a	С	С	ь	a	С	b	a	b
Question number	11	12	13	14	15	16	17	18	19	20
Answer	d	С	С	b	a	С	С	d	С	d
Question number	21	22	23	24	25	26	27	28	29	
Answer	С	d	С	С	b	b	С	d	d	

### **Answers** of essay questions

- (1) As it tends to gain or share one electron, and it has higher electronegativity than other elements.
  - (2) Because the oxidation number of hydrogen in calcium hydride melt is -1
- 31(1)(i)+1

(ii) - 1

(2) (i)  $-\frac{1}{2}$ 

(ii) - 2

$$(ii) + 7$$

$$(4)(i)+6$$

$$(ii) +4$$

$$(BrO)^{-}$$

Br + (-2) = -1

Br = +1

Br + 
$$(-2 \times 3) = -2$$

Br = +1

$$Br = +4$$

Bromine has been oxidized / As its oxidation number increased from +1 to +4

33 Sodium zincate Na₂ZnO₂

$$(+1 \times 2) + Zn + (-2 \times 2) = 0$$

$$\therefore$$
 Zn = +4 - 2 = +2

H₂S Oxidation S

- The oxidizing agent is SO₂
- The reducing agent is H₂S

$$(Cr_2O_7)^{2-}$$
  $Cr^{3+}$   
 $Cr = +6$   $Cr = +3$   
Reduction

- * Oxidizing agent is Cr₂O₇²
- (2) 6 electrons, and the source of these electrons is H₂S
- 36 (1) Element (D) / Electronic configuration: [Ar],  $4s^2$ ,  $3d^5$ Oxidation numbers: (+2, +3, +4, +5, +6, +7).
  - (2) Element (A).



$$N + (-2 \times 3) = -1$$

$$N = +5$$

### (2) Cation: (NH₄)⁺

$$N + (+1 \times 4) = +1$$

$$N = -3$$

### **Answers of the higher-order questions**

Question number	Answer	Idea of answering
38	<b>b</b>	$4H_2SO_4 + 3H_2S + K_2Cr_2O_7 \longrightarrow$
		$7H_2O + K_2SO_4 + 3S + Cr_2(SO_4)_3$
*		Obviously, the oxidation number of sulphur in
		sulphate group $(SO_4^{2-})$ does not change in any of its compounds.
		It does not participate in the oxidation-reduction process.
		Sulphur of H ₂ S is exposed to an oxidation process.
		$:: 3H_2S \longrightarrow 3S$
		$S = -2 \qquad S = 0$
		No. of moles of sulphur atoms which are exposed to oxidation is 3
		:. The correct choice is (b)

**9** (1) (i) (W).

(ii) (X).

**(2)** -2

### Answers of the exam model of chapter 🙎 🕽

### **Answers of multiple choice questions**

Question number	1	2	3	4	5	6	7	8	9	10
Answer	b	С	d	a	b	d	С	d	d	d

Question number	11	12	13	14	15	16	17	18	19	20
Answer	a	b	d	b	b	b	a	b	С	d

### **Answers of essay questions**

- 21 * The hydroxy formula of HIO is I(OH)
  - * The hydroxy formula of HClO₃ is ClO₂(OH)
  - : HClO₃ is stronger / Because the strength of the oxygenated acid increases with increasing the number of oxygen atoms nonbinded to hydrogen in this acid.
- It means that the distance between the centers of the nuclei of each of Na⁺ and Cl⁻ ions which are combined in the formula unit of NaCl crystal equals 2.79 Å
- 23 10 Ne: [He], 2s², 2p⁶

11Na: [Ne], 3s1

* Due to the stability of the electronic system of neon and the difficulty of the separation of an electron from a completely filled energy level.

# Answers of the exam models

### Including

- Answers of the exam of the Ministry of Education 2021
- * Answers of the guiding model of the Ministry of Education 2020
- * Answers of the guiding model of the Ministry of Education
- *Answers of 15 exam models on the curriculum of the first term.

### Answers of the questions of 2021 as in

Question number	1	2	3	4	5	6	7	8	9	10
Answer	d	d	a	c	d	d	С	С	b	a

Question number	11	12	13	14	15	16	17	18	19	20
Answer	b	d	c	a	d	b	a	С	d	a

Question number	21
Answer	b



### Answers of the questions of 2020 exam

Question number	1	2	3	4	5	6	7	8	9	10
Answer	d	a	d	b	С	d	a	b	d	d

Question number	11	12	13	14	15	16	17	18	19	20
Answer	a	b	c	b	c	С	С	d	a	b

Question number	21	22	23	24	25	26	27	28	29	30
Answer	a	a	a	d	d	d	a	С	b	d

Question number	31	32	33	34	35	36	37	38	39
Answer	d	a	С	a	a	b	d	b	a

#### Answers of the guiding model

Question number	1	2	3	4	5	6	7	8	9	10
Answer	d	b	a	d	С	b	a	a	b	a

Question number	11	12
Answer	c	С



Question number	1	2	3	4	5	6	7	8	9	10
Answer	b	d	d	a	С	С	b	a	b	a

Question number	11	12	13	14	15	16	17	18	19	20
Answer	С	С	d	d	a	С	b	d	С	a

Question number	21
Answer	a

- Oxidation number of the element = +2Because the electronic configuration of the element ends with the sublevel  $ns^2$ , so its atom tends to lose two electrons to give a positive ion that carries two positive charges.
- Electron (X) / As the sum of  $(n + \ell)$  of 4f sublevel (4 + 3 = 7) of the electron (X) is higher than the sum of  $(n + \ell)$  of 6s sublevel (6 + 0 = 6) of the electron (Y).
- (1) : Number of elements of s-block = 12 elements.

  Number of elements of p-block = 36 elements.
  - $\therefore$  The difference between them = 36 12 = 24 elements.
  - (2) Elements of f-block.



Number of completely filled orbitals = 
$$1 + 1 + 3 + 1 + 3 + 1 = 10$$
 orbitals.  
Number of partially occupied orbitals =  $3$  orbitals.

$$(n=4)$$
,  $(l=1)$ ,  $(m_l=-1)$ ,  $(m_s=+\frac{1}{2})$ .

Question number	1	2	3	4	5	6	7	8	9	10
Answer	a	c	С	b	d	b	c	a	a	b

Question number	11	12	13	14	15	16	17	18	19	20
Answer	a	c	b	a	b	b	b	a	С	d

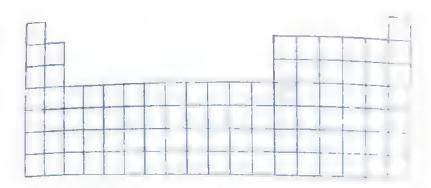
Question number	21
Answer	c

The second set / As it represents the electron of 4s sublevel that occupies the  $4^{th}$  energy level which is the farthest from the nucleus.

- (1) : Number of representative elements = 43 elements.

  Number of main transition elements = 40 elements.
  - $\therefore$  The difference between them = 43 40 = 3 elements.

(2)



24 (1) (C)

(2)(D)

- $\sim$  NaClO₃ / Where the oxidation number of chlorine = +5
- $26 \text{ Al}_2\text{O}_{3(s)} + 3\text{H}_2\text{SO}_{4(aq)} \longrightarrow \text{Al}_2(\text{SO}_4)_{3(aq)} + 3\text{H}_2\text{O}_{(1)}$
- 27 HClO / n = Zero

### Answers of exam model

3

Question number	1	2	3	4	5	6	7	8	9	10
Answer	b	С	d	С	a	С	d	b	a	b

Question number	11	12	13	14	15	16	17	18	19	20
Answer	c	a	d	d	a	a	b	С	ь	d

Question number	21
Answer	b



- $\mathcal{L}$ : The electron configuration of element X ends with the sublevel  $4s^{I}$ 
  - ∴ X is potassium 19K
  - ∴ KOH is ionized as a base, as its atomic size is large, and its ion carries one positive charge, so its attraction to oxygen ion O²⁻ decreases, and (O-H) bond becomes stronger than (K-O) bond, and hence negative hydroxide ion is formed.

$$KOH \longrightarrow K^{+} + OH^{-}$$

- The electrons are deflected towards the positive electrode / As they are negatively charged.
- 24 Cr: [Ar],  $4s^1$ ,  $3d^5$   25 Mn: [Ar],  $4s^2$ ,  $3d^5$

Yes / Due to the similarity between chromium and manganese, where the atom is more stable when 3d sublevel is half filled with electrons.

(2) MgO_(s) + H₂SO_{4(aq)} 
$$\longrightarrow$$
 MgSO_{4(aq)} + H₂O_(l)

Compound (X) Compound (Y) Compound (Z)

- Element (X) / As it requires to be excited to absorb an amount of energy sufficient for the electron to transfer from the lower energy level (n = 2) to the higher energy level (n = 6).
- (1) The bond length in the molecule of hydrogen chloride = r(H) + r(Cl) = 0.3 + 0.99 = 1.29 Å
  - (2) The bond length in the formula unit of sodium chloride =  $r(Na^+) + r(Cl^-) = 0.95 + 1.81 = 2.76 \text{ Å}$

-			
	1		T
	4		
		_	4
		_	

Question number	1	2	3	4	5	6	7	8	9	10
Answer	С	d	c	d	a	a	С	d	С	b

Question number	11	12	13	14	15	16	17	18	19	20
Answer	a	С	b	a	d	С	b	a	d	a

Question number	21
Answer	b

- The electronic configuration:  $1s^2$ ,  $2s^2$ ,  $2p^6$ ,  $3s^2$ ,  $3p^1$ Atomic number = 13
- The electronic configuration of the element: [Ne],  $3s^2$ ,  $3p^4$ . The element is located in the third period, group 6A (16).
- 24 [Ar],  $4s^2$ ,  $3d^{10}$ ,  $4p^3$
- 25 (1) Zero.
  - (2) Zinc (Zn) and sulphur (S) combine together to form zinc sulphide.
- Atomic radius of hydrogen =  $\frac{\text{Bond length in hydrogen molecule}}{2}$  $r(H) = \frac{0.6}{2} = 0.3 \text{ Å}$

Atomic radius of nitrogen =

Bond length in NH₃ molecule – Atomic radius of hydrogen r(N) = 1 - 0.3 = 0.7 Å



Atomic radius of oxygen =

Bond length in H₂O molecule - Atomic radius of hydrogen

$$r(O) = 0.96 - 0.3 = 0.66 \text{ Å}$$

Bond length in NO molecule =

Atomic radius of nitrogen + Atomic radius of oxygen

$$r(N) + r(O) = 0.7 + 0.66 = 1.36 \text{ Å}$$

- (1) The atomic numbers of these elements.
  - (2) All of them are metalloids.

### Answers of exam model



Question number	1	2	3	4	5	6	7	8	9	10
Answer	С	b	b	d	a	c	b	d	d	b

Question number	11	12	13	14	15	16	17	18	19	20
Answer	a	b	С	С	a	d	d	d	d	b

Question number	1	21
Answer	+	b

22 Bromine: - 324.5

lodine: - 295

Each principal energy level consists of a number of energy sublevels equals its number (n value = Number of l values).

- (1) Dalton's theory.
  - (2) Compounds are formed by the combination of atoms of different elements in a simple numerical ratio.
- $2RbOH_{(aq)} \longrightarrow 2RbOH_{(aq)}$
- (1) The electronic configuration:  $1s^2$ ,  $2s^2$ ,  $2p^6$ ,  $3s^2$ ,  $3p^1$   $\therefore$  The atomic number = 13
  - (2) Group number 3A (13).
- $r (O) = \frac{1.32}{2} = 0.66 \text{ Å}$  r (H) = 0.96 - 0.66 = 0.3 Å $2r (H_2) = 2 \times 0.3 = 0.6 \text{ Å}$

Question number	1	2	3	4	5	6	7	8	9	10
Answer	d	b	d	b	С	d	b	b	b	С

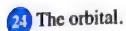
Question number	11	12	13	14	15	16	17	18	19	20
Answer	a	a	a	С	С	С	d	С	b	С

Question number	21
Answer	b

$$n = 5$$
 ,  $l = 1$  ,  $m_l = 0$  ,  $m_s = +\frac{1}{2}$ 

$$m = 3$$
 ,  $\ell = 0$  ,  $m_{\ell} = 0$  ,  $m_{s} = +\frac{1}{2}$ 

48



- Because the values of the electron affinity of these elements are nearly zero, where the atom becomes more stable when the sublevels:
  - 1s, 2s, 3s are completely filled as in He, Be, Mg
  - 2p, 3p are completely filled as in Ne, Ar
  - 2p is half filled as in N

And adding a new electron to any of these atoms decreases its stability.

- 26 (1) (B) and (C).
  - (2) The charge of the nucleus is similar to the charge of positive alpha particles, so it repels them on approaching to it.
- (1) * SO₂ oxide.
  - * Oxidation number:  $SO_2^{?-2}$ ,  $S + (-2 \times 2) = 0$ ,  $\therefore S = +4$
  - (2) * Cl2O oxide.
    - * The equation : Cl₂O + H₂O → 2HClO

### Answers of exam model



Question number	1	2	3	4	5	6	7	8	9	10
Answer	С	a	c	b	С	d	d	С	b	С

Question number	11	12	13	14	15	16	17	18	19	20
Answer	c	c	c	С	d	С	b	b	d	d

Question number	21
Answer	b

- Zero / As potassium is among the elements of group (1A), where the oxidation number of any metal in this group in its compounds = +1
- 23 2 electrons.
- No / Because the ionization potential of phosphorus 15P is higher than that of sulphur 16S despite the fact that it precedes sulphur in the same period.

$$_{15}P: [Ne], 3s^2, 3p^3$$

$$_{16}$$
S: [Ne],  $3s^2$ ,  $3p^4$ 

This is because the atom is more stable when 3p sublevel is half filled as in case of phosphorus, so removing an electron from this atom decreases its stability.

- 25 Q / s-block.
- 26 (1) (1) CO₂
  - (2) H₂O
  - (3) K₂CO₃
  - (2) The oxygenated acid :  $H_2CO_3$

The hydroxy formula: CO(OH)2

$$n=1 , m=2$$

- (1) (1) CI CI
  - D
  - (3) Br Br

(4) F - F

(2) I - I

2) r(H) + r(Cl) = 0.3 + 0.99 = 1.29 Å

Question number	1	2	3	4	5	6	7	8	9	10
Answer	b	ь	С	d	d	a	С	d	b	d

Question number	11	12	13	14	15	16	17	18	19	20
Answer	a	a	b	d	a	d	С	С	d	С

Question number	21
Answer	d

- 22 XCl₂
- Sulphuric acid H₂SO₄ / As it is more active, where the number of oxygen atoms nonbinded with hydrogen in sulphuric acid SO₂(OH)₂ is higher than in ClO(OH)₂
- Number of the representative elements in the first period = 1 element. Number of the representative elements in the second period = 7 elements. The difference between them = 7 - 1 = 6 elements.
- (2)  $(1) (1) 1s^{J}$  (2)  $Is^{2}, 2s^{2}, 2p^{3}$  (2) Zero.
- Quantum numbers n  $\ell$   $m_{\ell}$   $m_{s}$ First electron 2 1 -1  $+\frac{1}{2}$ Second electron 2 1 -1  $-\frac{1}{2}$

- (1) Dalton's theory.
  - (2) The element is composed of very minute particles called atoms.

Question number	1	2	3	4	5	6	7	8	9	10
Answer	d	С	a	d	С	a	a	b	c	c

Question number	11	12	13	14	15	16	17	18	19	20
Answer	b	С	С	С	d	a	a	c	С	b

Question number	21
Answer	a

- 22: The electronic configuration of the element ends with  $3p^4$  sublevel.
  - .. The element is located in the third period, group 6A (16).

23 
$$X: 1s^2, 2s^2, 2p^6, 3s^1$$

$$Y: 1s^2, 2s^2, 2p^6, 3s^2, 3p^4$$

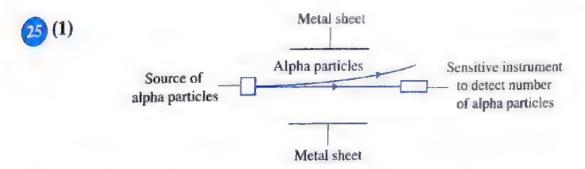
$$Z: 1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2$$

Element X / Because this results in breaking a completely filled energy level.

### Sulphuric acid: SO₂(OH)₂

Sulphurous acid: SO(OH)2

.. Sulphuric acid is more acidic / As the strength of the oxygenated acid increases by increasing the number of nonbinded oxygen atoms with hydrogen.



(2) The reading of the sensitive instrument decreases.

$$r (H) = 1.29 - 0.99 = 0.3 \text{ Å}$$

$$2r (H_2) = 2 \times 0.3 = 0.6 \text{ Å}$$

$$r (N) = 1 - 0.3 = 0.7 \text{ Å}$$

$$2r (N_2) = 2 \times 0.7 = 1.4 \text{ Å}$$

.. Bond length in nitrogen molecule (N₂) is longer than that in hydrogen molecule (H₂).

27 Cr: 
$$4s^{1}$$
,  $3d^{5}$ 

$$Cu:4s^l$$
,  $3d^{l0}$ 

### Answers of exam model 10

Question number	1	2	3	4	5	6	7	8	9	10
Answer	c	С	a	a	d	d	b	a	d	d

Question number	11	12	13	14	15	16	17	18	19	20
Answer	c	d	d	d	a	С	d	b	c	b

	Question number	21
1	Answer	b

- 22 d-block.
- 23 HO
- 24 Acid (3) > Acid (1) > Acid (2).

		First group	Second group
Elen	nents	1, 2, 4, 5	3,6
Typ	e of nents	Representative elements	Noble elements

- (1) The electronic configuration:  $1s^2$ ,  $2s^2$ ,  $2p^6$ ,  $3s^2$ ,  $3p^6$ ,  $4s^2$ ,  $3d^{10}$ ,  $4p^3$ Number of completely filled orbitals = 1 + 1 + 3 + 1 + 3 + 1 + 5= 15 orbitals.
  - (2) 3 electrons.



Question number	1	2	3	4	5	6	7	8	9	10
Answer	d	С	С	С	С	a	b	d	С	b

Question number	11	12	13	14	15	16	17	18	19	20
Answer	d	a	b	d	a	b	c	b	d	a

Question number	21
Answer	a

- No / Due to the similarity of the two electrons of *ls* sublevel in all four quantum numbers.
- $M: 1s^2, 2s^2, 2p^6, 3s^1$ Because the second ionization potential of the element M is very high, where it causes breaking of a completely filled energy level.
- $(ClO_3)^-$  Reduction  $Cl^-$ ,  $(ClO_3)^-$  Reduction  $(ClO_3)^ (ClO_3)^ $

Oxidizing agent : (ClO₃) Reducing agent : I

- 25 Figure (2) / Bohr.
- (1) The electronic configuration :  $1s^2$ ,  $2s^2$ ,  $2p^3$ • The location : Second period, group 5A (15).
  - (2) p-block.
- 27 (1) 29 elements.
  - (2) [Ar],  $4s^2$ ,  $3d^{10}$ ,  $4p^2$

12

Question number	1	2	3	4	5	6	7	8	9	10
Answer	d	С	d	С	d	d	С	d	a	c

Question number	11	12	13	14	15	16	17	18	19	20
Answer	b	a	d	a	d	a	b	С	b	С

Question number	21
Answer	С

Because p sublevel contains three orbitals, each orbital is filled with 2 electrons.

23  $Co^{3+}$ : [Ar],  $4s^0$ ,  $3d^6$ 

.. Number of unpaired electrons : 4 electrons.

21 Representative, main transition, inner transition and noble elements.

(1) Dalton's theory.

(2) Masses of the atoms of the same element are similar, but they differ from an element to another.

26 (1) First ionization potential.

(2) Used in detecting invisible alpha particles, where it flashes when these particles collide with it.

(1) : The hydroxy formula of the acid: PO(OH)3

... Number of nonbinded oxygen atoms with hydrogen in this acid = 1

(2)  $3MgO + 2H_3PO_4 \longrightarrow Mg_3(PO_4)_2 + 3H_2O$ 



Question number	1	2	3	4	5	6	7	8	9	10
Answer	c	a	c	d	a	b	a	d	b	b

Question number	11	12	13	14	15	16	17	18	19	20
Answer	d	d	c	b	c	c	d	b	d	d

Question number	21
Answer	c

$$2 r(Li^{+}) + r(Cl^{-}) = 0.68 + 1.81 = 2.49 \text{ Å}$$

- 2 Yes / As the cathode rays move in straight lines.
- B, C and D / Because the excited electron transfers in the atom from higher energy level to lower energy level (its ground state).

$$(2) + 6$$

- (1) : Compound (Y) : ZnSO₄
  - ... The electronic configuration of the cation  $\mathbf{Z}\mathbf{n^{2+}}:[\mathrm{Ar}]$ ,  $3d^{10}$
  - (2) Sodium zincate.

(1) Case (1): 
$$l = 0$$
 ,  $m_{\ell} = 0$   
Case (2):  $l = 1$  ,  $m_{\ell} = 0$   
(2)  $n = 1$ 

14

Question number	1	2	3	4	5	6	7	8	9	10
Answer	b	a	a	c	d	d	a	a	c	b

Question number	11	12	13	14	15	16	17	18	19	20
Answer	С	c	d	b	d	a	a	b	a	c

Question number	21
Answer	c

22 d-block.

23 :: Sublevels : 5s , 5p , 5d , 5f

 $\therefore$  Number of orbitals = 1 + 3 + 5 + 7 = 16 orbitals.

24 7.7% (H): 92.3% (C)

As the proportions (ratios) of the components of the compound remain constant, no matter how different its mass, according to Dalton's postulate.

(BrOH), as the strength of the acid increases by increasing the number of nonbinded oxygen atoms with hydrogen.



(2) 
$$\frac{+1?}{\text{HBrO}}$$
,  $1 + \text{Br} - 2 = 0$ 

$$\therefore$$
 Br = +1

$$^{+1?}_{HBrO_4}^{-2}$$
,  $1 + Br + (-2 \times 4) = 0$  ::  $Br = +7$ 

$$\therefore Br = +7$$

(1) The electronic configuration of the element (C): [Ne],  $3s^2$ ,  $3p^1$ 

The quantum numbers of the last electron in the atom of the element (D)

$$n=3$$
 ,  $l=1$  ,  $m_l=0$  ,  $m_s=+\frac{1}{2}$ 

(2) 
$$E_2O_5 + 3H_2O \longrightarrow 2H_3EO_4$$

(1) Because increasing the number of positive protons more than that of negative electrons results in increasing the nucleus effective charge leading to decreasing the size of the ion.

(2) Ca: 
$$1s^2$$
,  $2s^2$ ,  $2p^6$ ,  $3s^2$ ,  $3p^6$ ,  $4s^2$ 

Number of orbitals = 1 + 1 + 3 + 1 + 3 + 1 = 10 orbitals.

#### Answers of exam model

Question number	1	2	3	4	5	6	7	8	9	10
Answer	d	С	a	b	d	a	c	a	С	d

Question number	11	12	13	14	15	16	17	18	19	20
Answer	a	d	c	d	b	a	b	d	b	b

Question number	21
Answer	b

(1) 7A (17) / Because the 8th ionization potential of element (Y) is much higher than its 7th ionization potential.

(2) (X): 
$$1s^2$$
,  $2s^2$ ,  $2p^6$ ,  $3s^2$ ,  $3p^4$ 

- (1) Dalton's theory.
  - (2) Compounds are formed by the combination of atoms of different elements in simple numerical ratios.
- 24 (1) Yes.
  - (2) Alpha particles: Are deflected slightly towards the negative electrode.

**Beta particles :** Are deflected significantly towards the positive electrode.

- Symbol : F Block : p
- 26  $\operatorname{Se}_{(g)} + e^{-} \longrightarrow \operatorname{Se}_{(g)}^{-} + \operatorname{Energy}$ ,  $\Delta H = (-)$
- $^{27}_{29}\text{Cu}^+: [\text{Ar}], 3d^{10}$  $_{30}\text{Zn}^{2+}: [\text{Ar}], 3d^{10}$